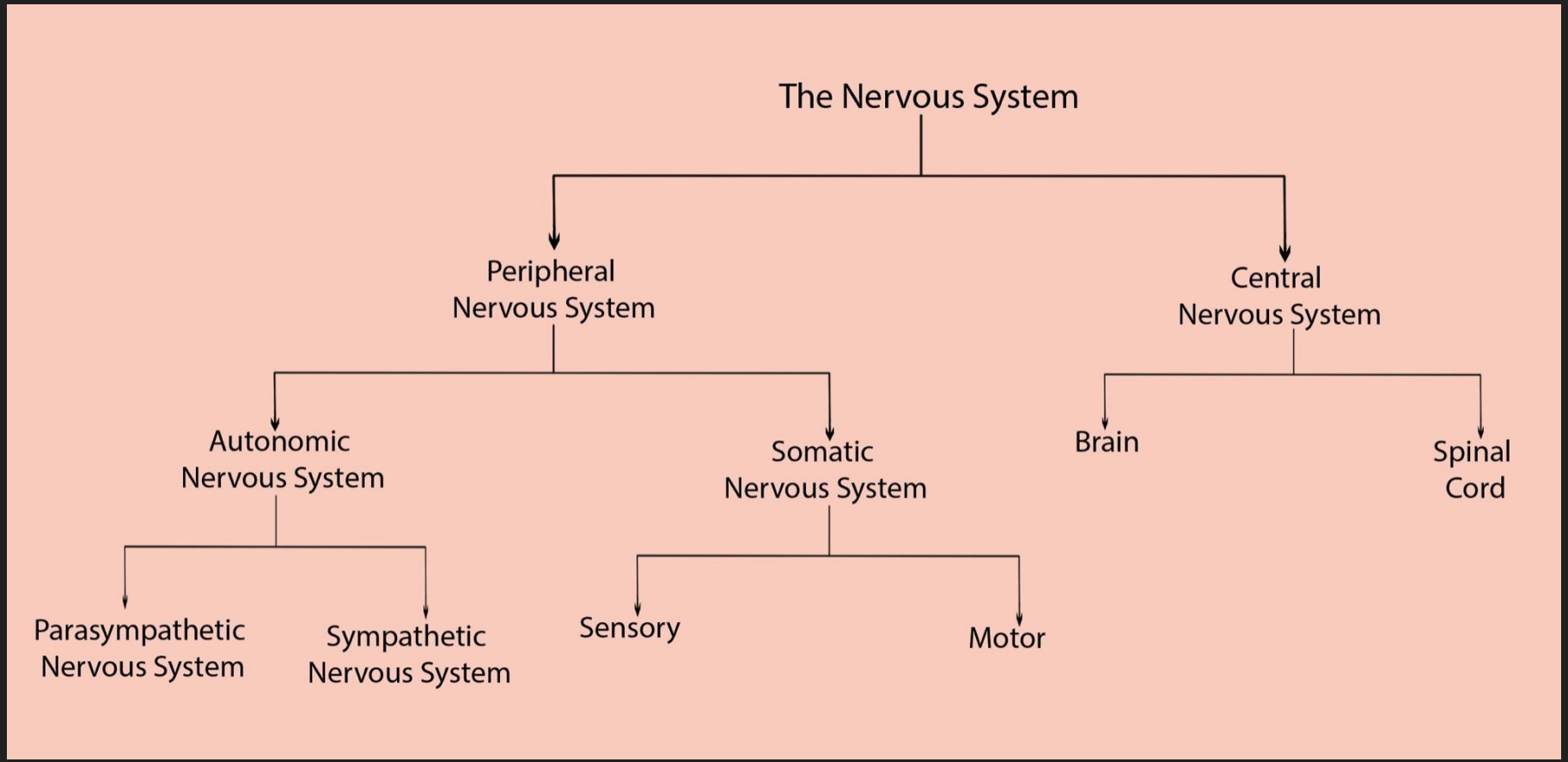
# Summary of Chapter 13

Mr Shousha

# Nervous System Organization



# Key Takeaways

1. The Nervous System is made up of:
    a. Central Nervous System (CNS)
        i. Brain and spinal cord
        ii. Coordinates information flow (in and out)

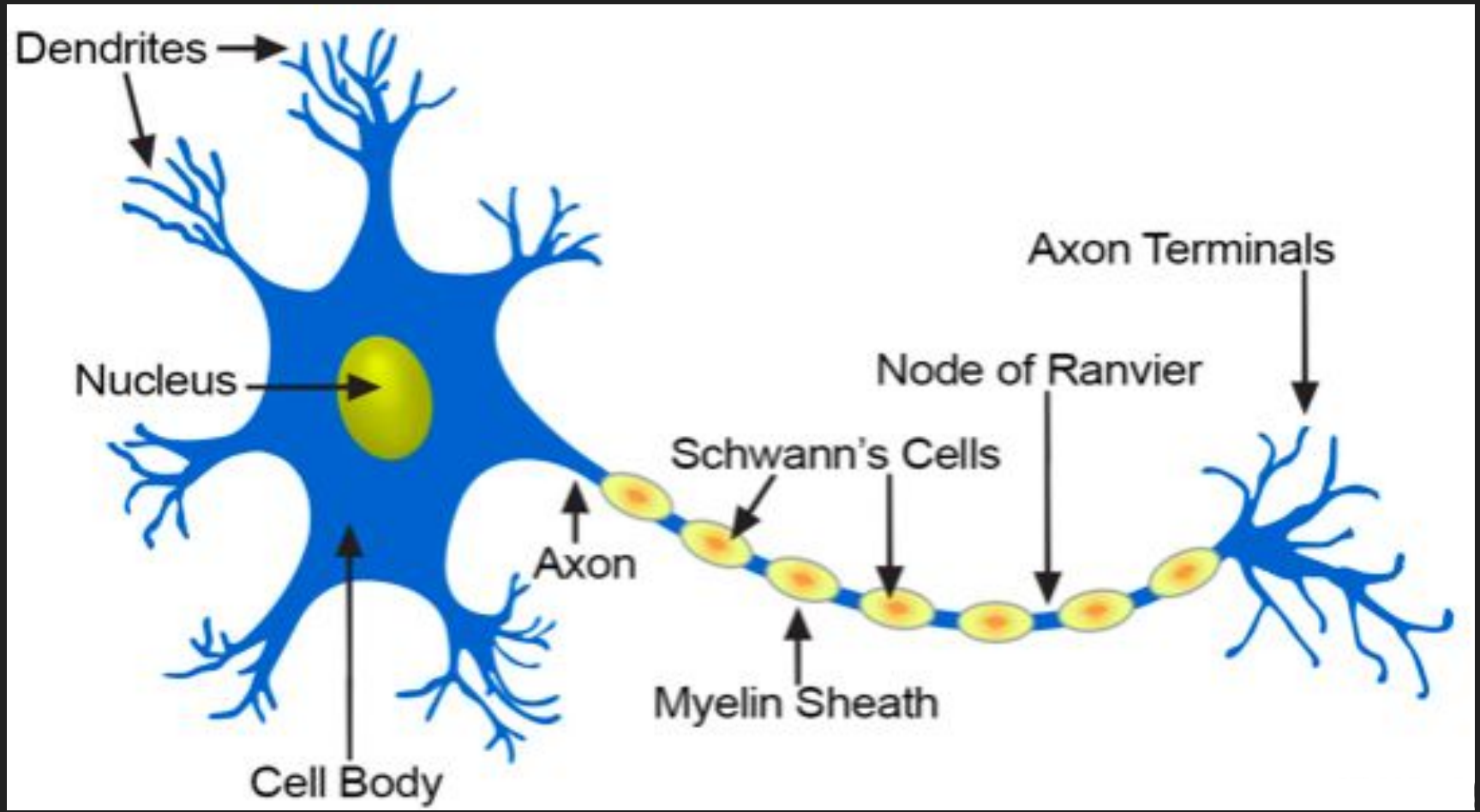
    b. Peripheral Nervous System (PNS)
        i. Somatic NS (*voluntary*)
            - Sensory and motor nerves
        ii. Autonomic (*involuntary*)
            - Parasympathetic (Relaxed state)
            - Sympathetic nervous system (Stress state)

# 2 Types of Nerve Cells

1. Glial/Neuroglial Cells
    a. Nonconducting (no action potentials)
    b. Supports Structure + Metabolism
        i. E.g. Schwann cells

1. Neurons
    b. Conducting (produces action potentials)

# Anatomy of the Nerve Cell


Dendrites
Nucleus
Cell Body
Axon
Schwann's Cells
Myelin Sheath
Node of Ranvier
Axon Terminals

1. Dendrites: carry action potentials **TOWARDS** the cell body
2. Cell Body: coordinates tasks for cell function + transmits NI
    - Contains the nucleus
3. Axon: transmits NI **AWAY** from cell body
4. Myelin Sheath: insulates axon for faster NI (less charge loss)
    - White fat-protein
5. Schwann Cells: produce myelin/myelin sheath
6. Nodes of Ranvier: gaps in axon
    - Facilitate action potentials by saltatory conduction
7. Axon buds/terminals: releases neurotransmitters
    - Involved in synaptic transmission

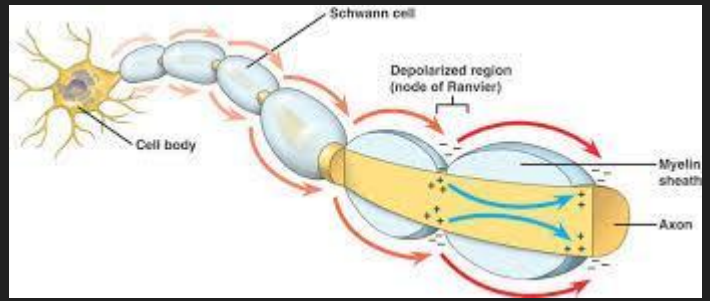
*Important Side Notes*

## *Factors that affect NI speed*

- Axon diameter (increased space for charge to flow)
- Myelination (increased insulation = less charge lost)

## *Saltatory Conduction*

- Creation of action potentials only at the nodes of ranvier in myelinated axons = increased speed
  - This allows the charge to hop from one node of ranvier to another



## PNS ONLY

Neurilemma: special structure ONLY in PNS (NOT CNS)

- Made by schwann cells + its function is to repair damaged axons

## CNS ONLY

White Matter: Myelinated nerve fibers

Grey Matter: Unmyelinated nerve fibers

- Note: PNS nerves are can also be described in this way also.

## *3 Classes of Neurons*

1. Sensory/Afferent Neurons: (PNS)
   - Relay sensory information/stimuli to the CNS
   - Stimuli is received from sensory receptors

2. Motor/Efferent Neurons: (PNS)
   - Relay motor information to effectors

3. Interneurons/association neurons: (CNS)
   - Neurons that link other neurons

# Receptors and Effectors

## Sensory Receptors:

- Activated by environmental changes or stimuli

## Effectors:

- Cell or organ that produces a physical response

Note: MOST Sensory Receptors and Motor Effectors are NOT Neurons

- For the purposes of biology 30, you can assume NONE are neurons

# *Reflex Arc*

- Simplest nerve pathway
- *Patellar reflex* (“knee-jerk” reaction) + *pupillary reflex* (eye)

## Neuron, Receptor, Effector Organization

1. Pathway for receiving sensory information

***Stimulus → receptor → sensory neuron→ interneuron****

1. Pathway for receiving motor information

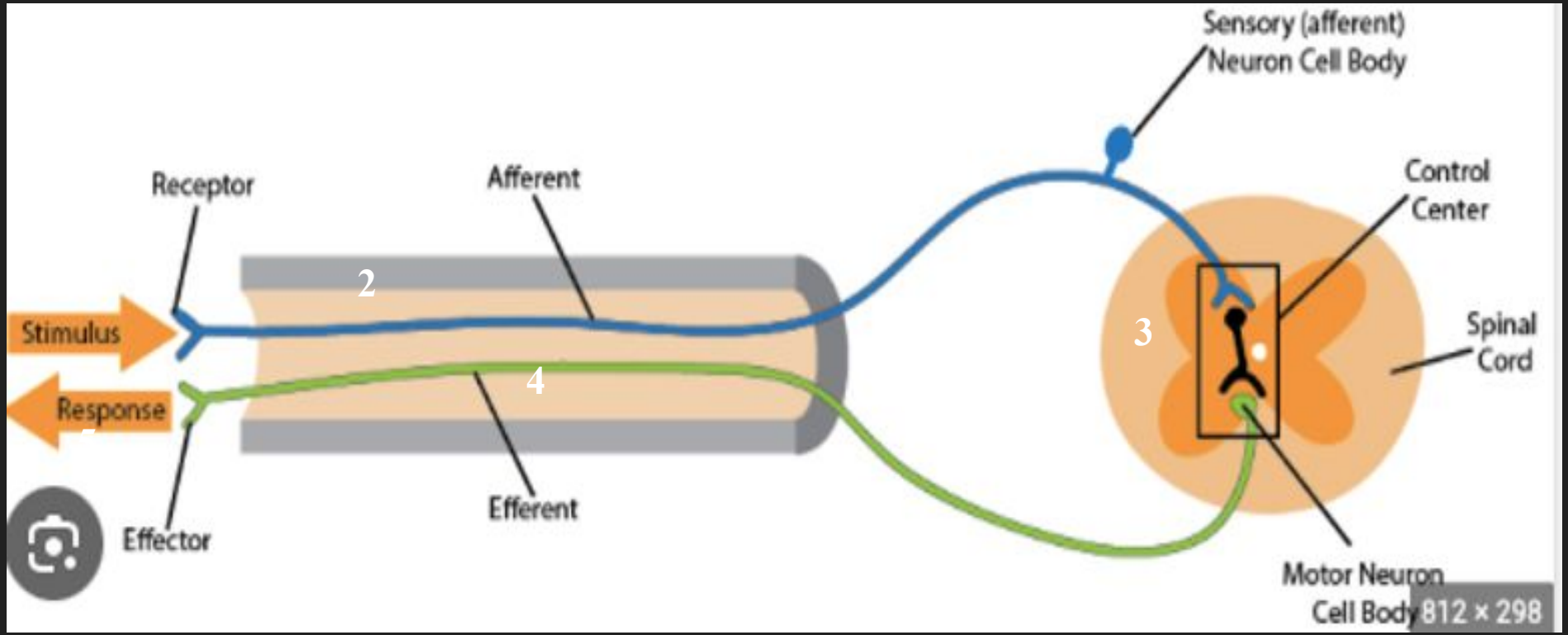
***Interneuron* → motor neuron → effectors*****

*Interneurons (brain and spinal cord)

**Effectors will produce a physical response

# Complete Neuron, Receptor, and Effector Organization**

Stimulus → sensory neuron → interneuron → motor neuron → effector



## Patellar Reflex *READ OVER, DO NOT MEMORIZE*

1. Stimulus: Tap below the knee
2. Sensory Receptor: feels the tap on the knee
3. Sensory Neuron: relays the information to CNS
4. Interneuron (found in the spinal cord)
5. 2 Motor Neurons: relays the information to effectors
6. Effectors: Quadricep contracts and hamstring relaxes
    - Results in a kicking motion

## Pupillary Reflex *READ OVER, DO NOT MEMORIZE*

1. Stimulus: shining light
2. Sensory Receptor:
3. Sensory Neurons: (2) one for each eye
4. Interneuron (brain)
5. Motor neurons: (2) one for each eye
6. Effectors: eye muscles contract (pupils constrict)
    - Less light enters the eyes

# Electrochemical Impulses

# Background

The neuron is composed of both negative and positive ions ($K^+$, $Cl^-$, $Na^+$) inside and outside the cell.

Note: $Cl^-$(aq) is used to balance charges and isn't used to determine the voltage differences in at REST (-70 mV) or during an Action Potential (+40 mV)

- The inside of the neuron/cell = more (potassium) $K^+$
- The outside of the cell = more (sodium) $Na^+$

Note: $K^+$ movement mostly responsible for creating the electrical potential that ultimately produces an action potential

# Movement of Ions Across the Plasma Membrane

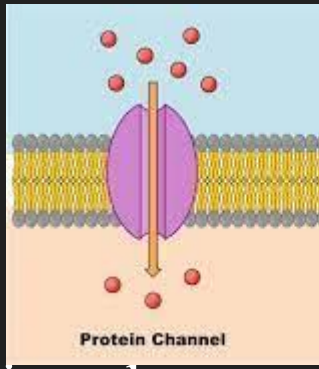
The cell/plasma membrane of the neuron is made up of a phospholipid bilayer making the membrane **selectively permeable.**

**Selective permeability**: some substances can pass through others cannot

- E.g. small nonpolar molecules pass easily ($CO_2$, $O_2$)
- E.g. ions can NOT pass without help of channel and carrier proteins

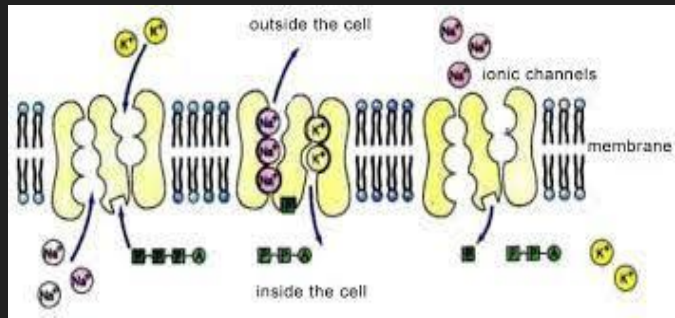
# 2 Ways of Ion Transport

1. Facilitated Diffusion: passive transport (no energy used) that involves ions passing through "Gated Ion Channels."*
   a. Follows the concentration gradient (High → Low)
   b. E.g. Potassium and Sodium Ion channels




*One type of transport protein

1. Active Transport: Carrier protein transport that moves against the concentration gradient (Low → High)*Requires energy*
   b. ONLY used during the refractory period
   c. E.g. Sodium Potassium Pump



# Sodium Potassium Pump

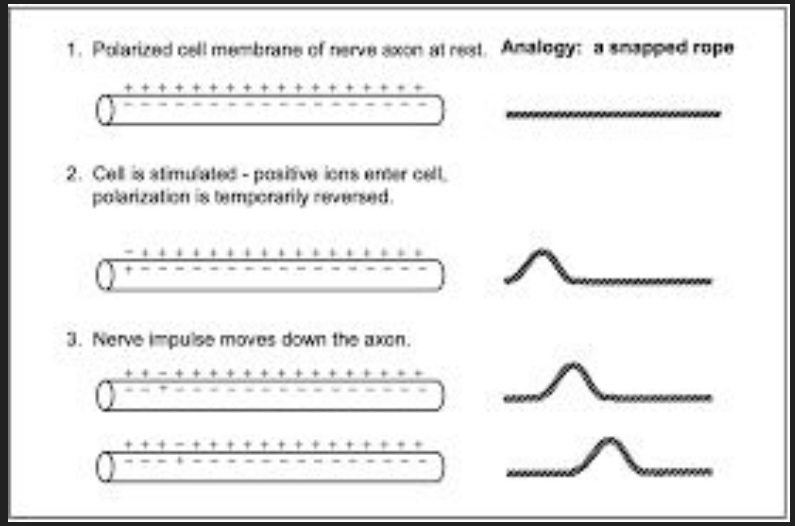
Function: Maintains the resting state (i.e. -70 mV)

→ note: this is not a state at “equilibrium”

Carrier protein = moves 3 Na+ out, and moves 2 K+ in.

# Important Terms

1. *Resting Potential:* voltage difference across a nerve cell AT REST (no transmissions/action potentials)
   a. -70 mV
2. *Action Potential:* voltage difference across a nerve cell when EXCITED
   a. +40 mV

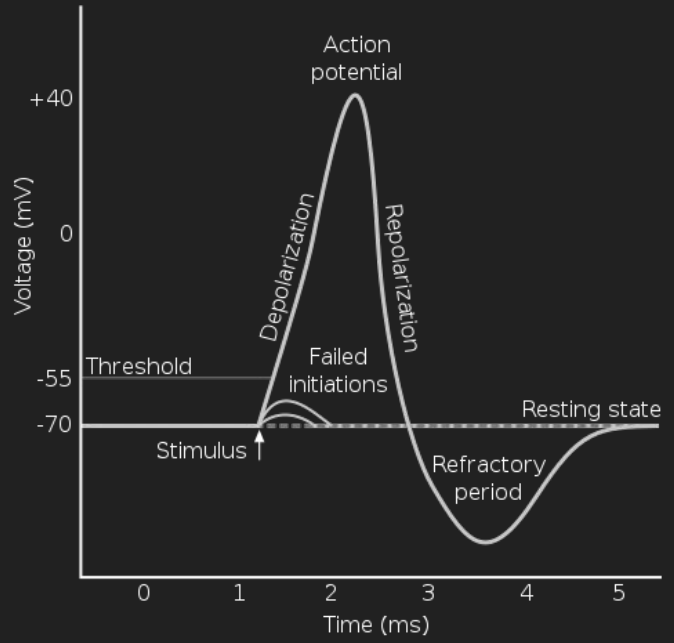



***Both represent the neuron to have a "polarized membrane"***

# The Steps of An Action Potential

An Action Potential has 4 main stages:

1. Depolarization
2. Repolarization
3. Hyperpolarization
4. Refractory Period



1. Depolarization:

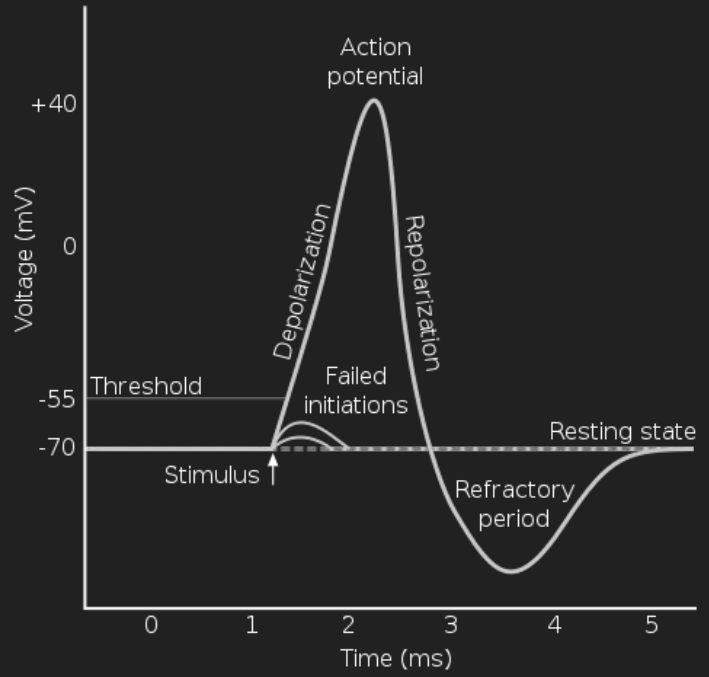
Nervous System receives a stimulus

- **Na+ channels open**, K+ channels close (Facilitated Diffusion)

→ Na+ more permeable (inside)

Plasma Membrane  goes from -70mV to +40mV.

**Action Potential occurs at +40mV

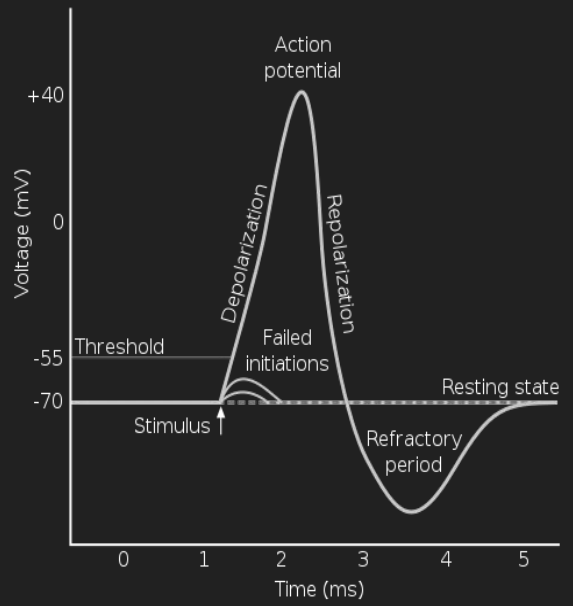


# 2. Repolarization:

- Na+ channels close, and **K+ channels open** (Facilitated Diffusion)

→ K+ more permeable (outside)

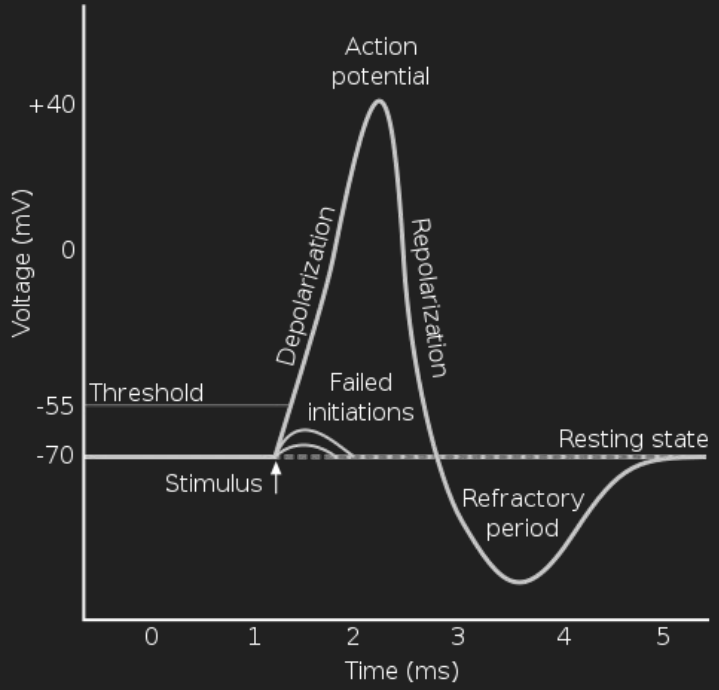
Purpose: restore the original resting potential (-70mV)



3. Hyperpolarization:

Because there are MORE K+ channels, more time is needed to close all the channels = voltage difference is overshot (past -70mV)

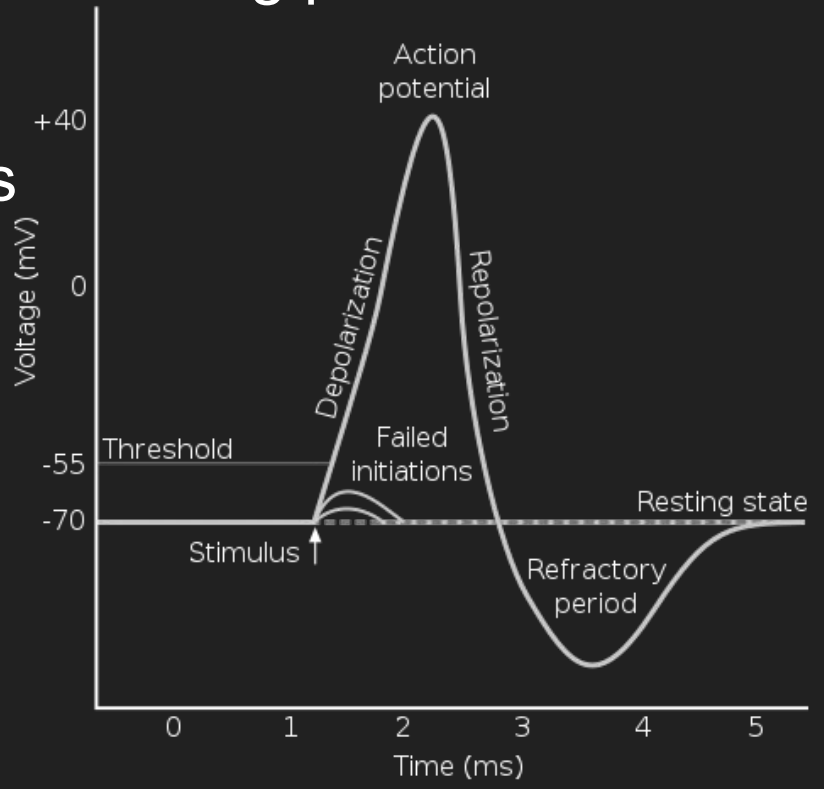
- +40 mV to -110 mV

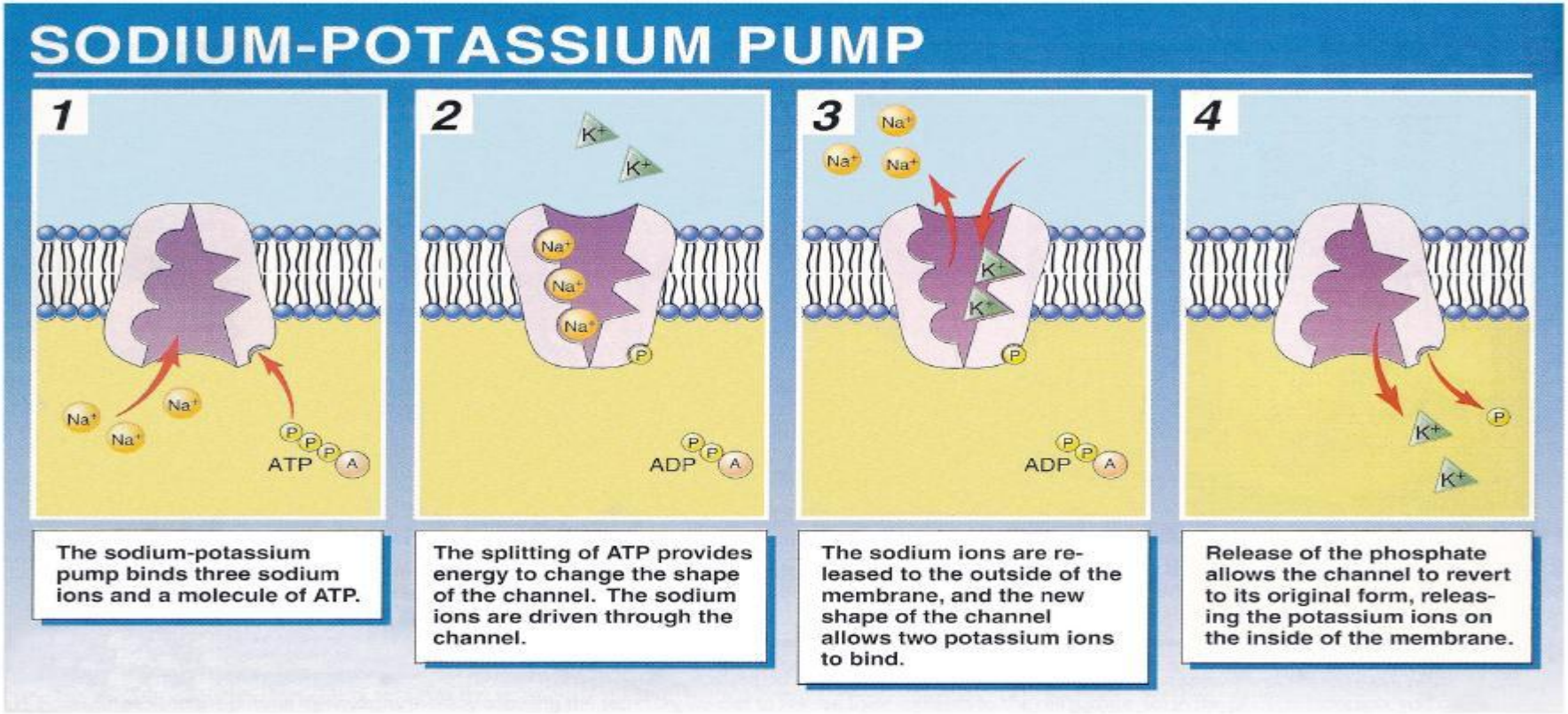


# 4. Refractory Period:

Period when the Na+/K+ pump restores resting potential

- Takes approximately 1-10 ms
- ONLY time active transport occurs






ONLY REMEMBER: K+ (2) enters and Na+ (3) exits cells

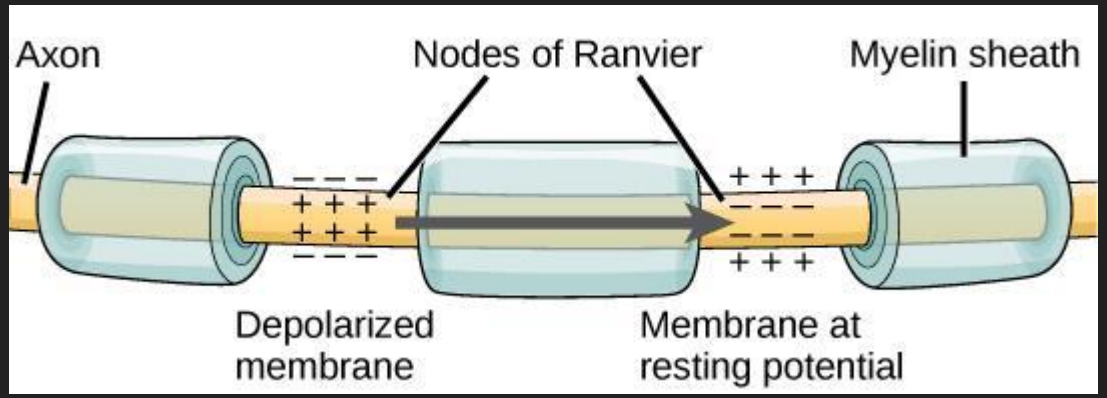
*2K3dom (2K“freedom”) **might help you remember**

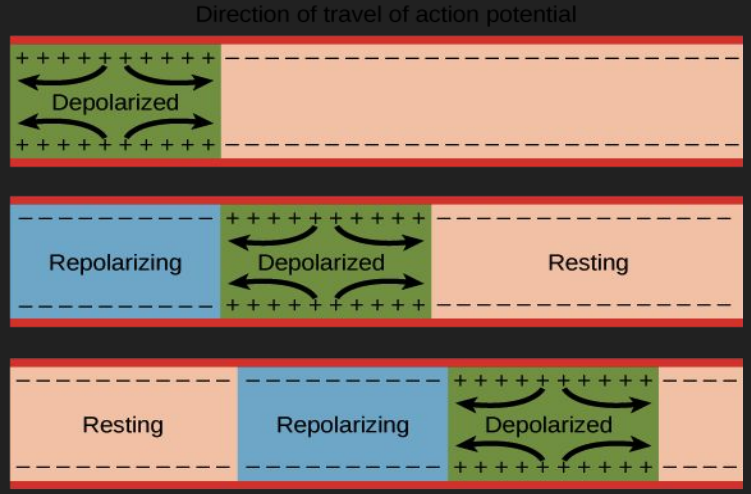
* dom = sodium

# Nerve Impulse Movement Across the Axon

## "Wave of Depolarization"

- Multiple action potentials are generated one after another
  - The action potential doesn't move
  - Caused by charge attraction of adjacent sections of the neuron



# Important Side Notes

1. Action potentials can't move backwards
    - Due to the refractory period. = Na+ channels are closed, which means no depolarization can occur (which requires Na+ channel to open).
1. ALL action potentials are the exact SAME! (same 4 steps)
    - **All-or-none response**
        - Any increase in stimulus intensity does NOT produce a greater response.
            - If stimulus intensity is at or above the threshold level = full response occurs
1. Difference in threshold levels of different neurons determine whether a neuron will produce an action potential
    - Threshold Levels: minimum stimulus intensity required to produce response
        - E.g. Neuron 1 (threshold level = 10 mV) vs Neuron 2 (threshold level = 20 mV)
            - Stimulus 1 = 10 mV = Neuron 1 (AP occurs) , Neuron 2 (NO AP)
            - Stimulus 2 = 20 mV = both Neuron 1 and 2 produce an AP

# Body's Way of Detecting different level of stimulus intensity

Because all action potentials are the SAME (speed and intensity)

- ALL or NONE Response

Differences in the stimulus intensity can be detected in 2 ways:

1. Variations in the frequency
   a. Higher frequency = more intense stimulus (e.g. hand over fire)
   b. Lower frequency = less intense stimulus (e.g. papercut on finger)

1. Number of Neurons Firing
   b. If more neurons are firing = stimulus is strong enough to activate neurons with higher threshold levels and ones with lower threshold levels
   c. If less neurons are firing = stimulus is NOT strong enough to activate neurons with higher threshold levels

# Synaptic Transmission

# Important Terminology

1. Synapses/Synaptic Cleft: Space between 2 neurons

1. Presynaptic neuron: Neuron that carries nerve impulse **TO** synapse

1. Postsynaptic neuron: Neuron that carries nerve impulse **AWAY** from synapse

1. Neurotransmitters: **chemical messengers** released by the presynaptic neuron end plates to the postsynaptic neuron receptors/dendrites
    a. Appear as small vesicles

# Neurotransmitters (NT)

Chemical Messengers that alter membrane potentials of postsynaptic neurons to either inhibit or initiate an action potential.

NT can be classified as either:

1. Excitatory
- Opens Na+ channels = depolarization (+) = AP
1. Inhibitory
- Opens K+ channels = hyperpolarization (-) = No AP

# List of Neurotransmitters

1. Acetylcholine: Excitatory (skeletal muscle) + Inhibitory (other locations)
    a. Function: muscle contraction
    **b. <u>Cholinesterase</u>** (enzyme): destroys acetylcholine after it's use
2. Norepinephrine: E + I
    a. Wakefulness
3. Dopamine: E
    a. General movement and emotions
4. Serotonin: I
    a. Sleep
5. GABA: I
    a. Motor behaviour

# NT Synaptic Transmission Steps

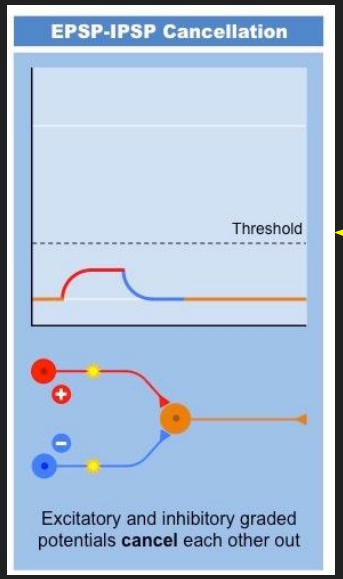
1. Action Potential reach terminal ends
2. NT vesicles (in storage) diffuse from the end plate to the synapse
3. NT interacts with postsynaptic neurons receptor to produce a response (+/- AP)
4. After NT Action, they need to be removed from the synapse.

   This occurs in 3 ways:

   - Diffusion (excess floating away)
   - Reuptake (reused NT)
     - Excess diffuses back to presynaptic neuron
   - Enzymes (destroy and recycle NT)
     - Reuse main components

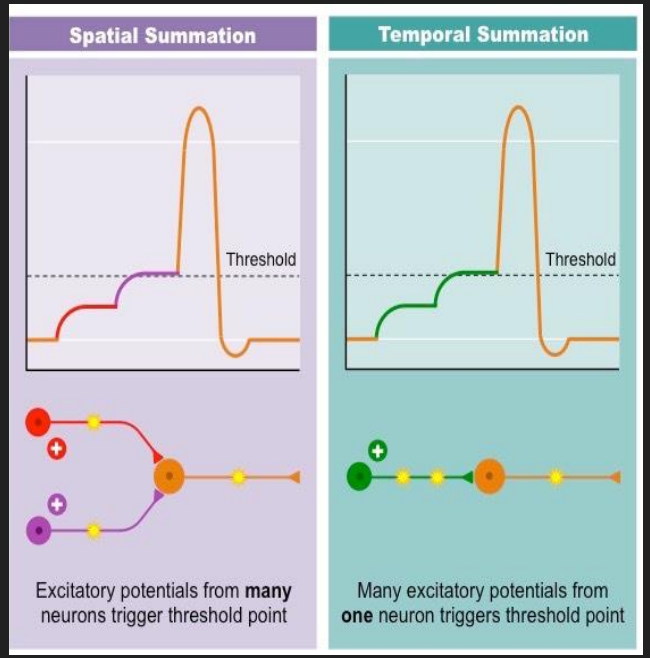
# Summation

- Action potential caused by the ***accumulation*** of neurotransmitters from two or more neurons
  - In these circumstances, the neuron's threshold is higher and therefore requires more stimulus.




Excitatory = AP

Inhibitory = NO AP



# Drugs and Summation

Psychoactive Drugs: group of legal and illegal drugs influencing the nervous system.

- These drugs disrupt the inflow and outflow of information
  - Disrupts either the movement OR attachment of NT

2 Main Classes

1. Depressants: drugs that mimic Inhibitory NT
2. Stimulants: drugs that mimic Excitatory NT

# Psychoactive drugs + Effects on Nervous System

**TRY TO UNDERSTAND THE REASONING, RATHER THAN MEMORIZE**

1. Depressants
- Block receptor sites (NT can’t connect)
- Decreases NT production + storage
- Increases NT breakdown

2. Stimulants
- Mimics excitatory NTs + stimulates receptors
- Decrease NT breakdown + diffusion
- Increases rate of excitatory NT production

# Central Nervous System

# Brain

Our CNS systems (brain and spinal cord) are protected from external forces/trauma by the ***Meninges***.

- Protective membrane in the spinal cord and brain

Note: The CNS is also protected by bone (i.e. skull (brain) and vertebrae (spinal cord))

- The spinal cord has a third way of protection = intervertebral discs
  - (metabolism and shock absorption)

# Meninges

Consists of 3 layers:

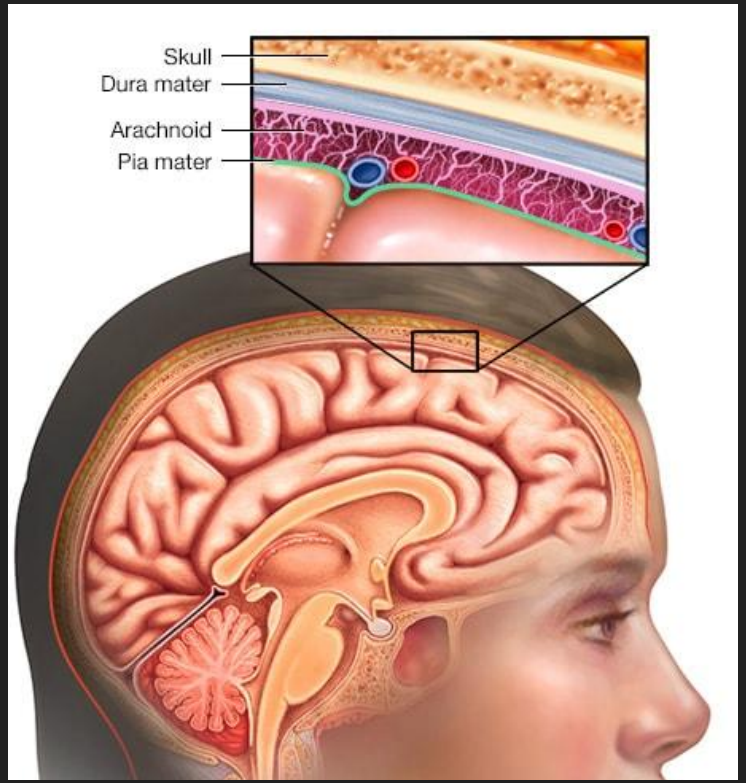
1. Dura mater (outer)
2. Arachnoid mater (middle)
3. Pia mater (inner)

*DAB*
way to memorize the order

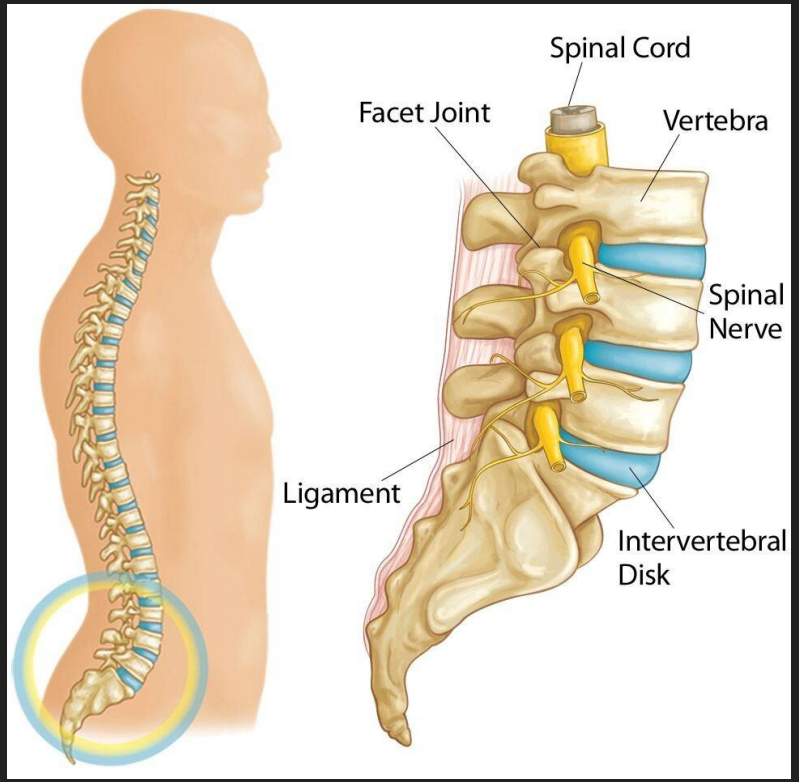
Further protection is provided by the Cerebrospinal Fluid

- Fluid between the inner and middle layers of the meninges
- Helps with shock absorption (reduce effect of impact) + metabolism

Brain Protection: Menigenes (with CS fluid) + Skull




Spinal Cord Protection: Vertebrae + Meninges (with CSF) + Intervertebral discs



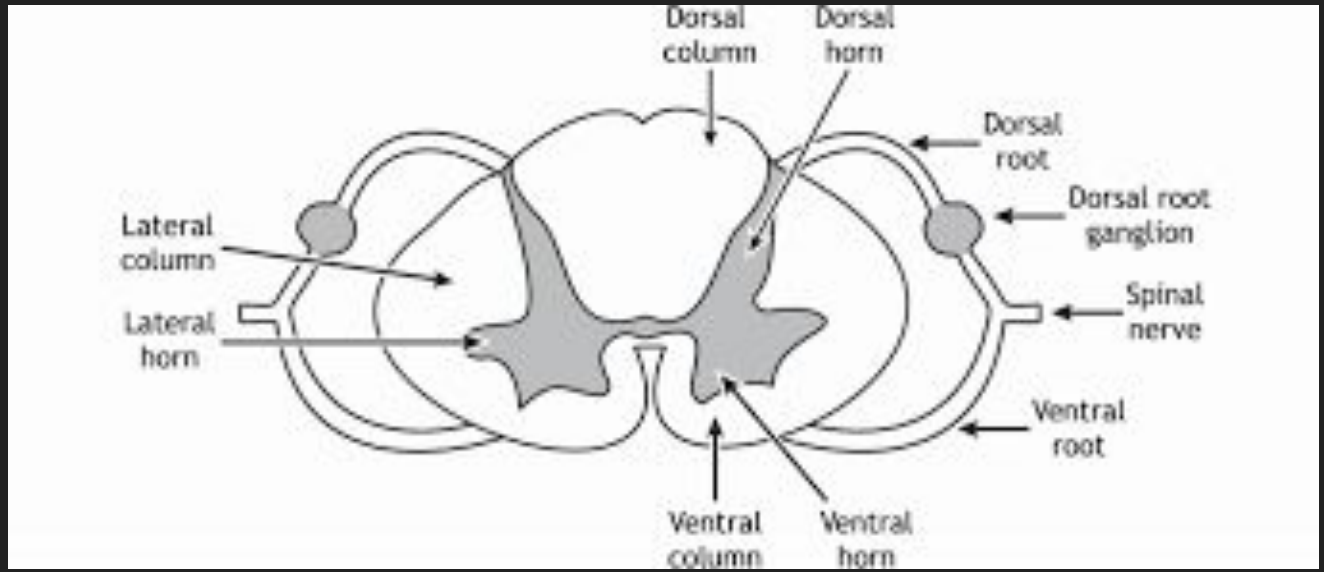

# Protection Summary

# Spinal Cord

The spinal cord connects to the brain through the ***Foramen Magnum***

- Hole in the skull

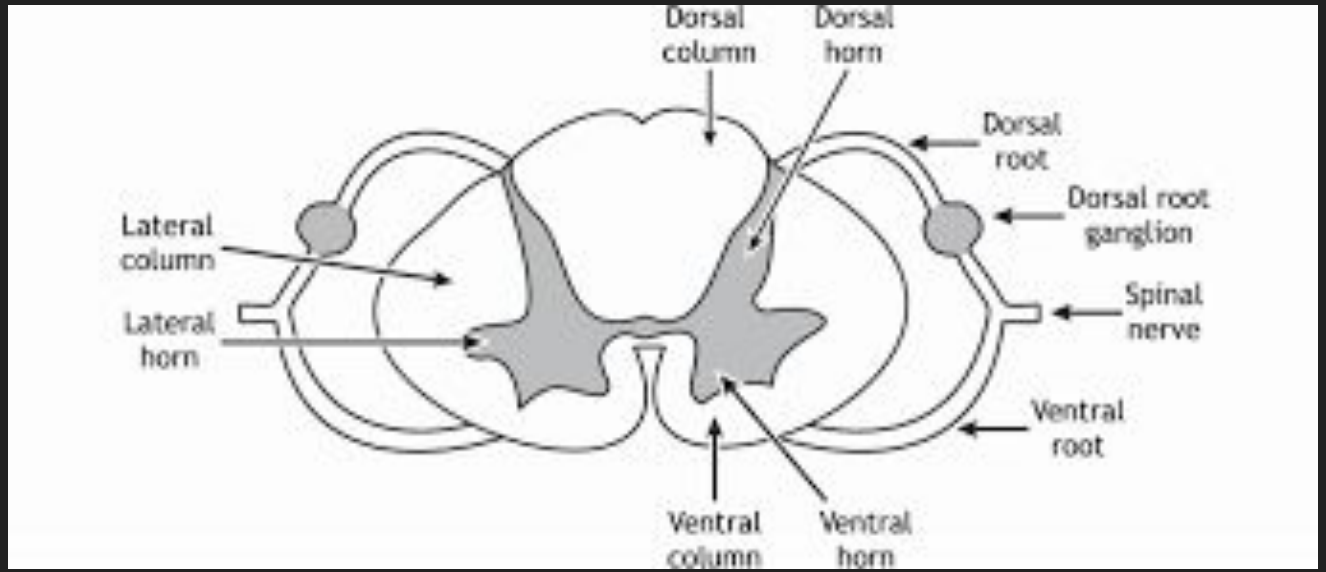
The spinal cord consists of white (sensory and motor neurons) and grey matter (interneurons):



# Spinal Cord

Dorsal root: relays sensory information (back)

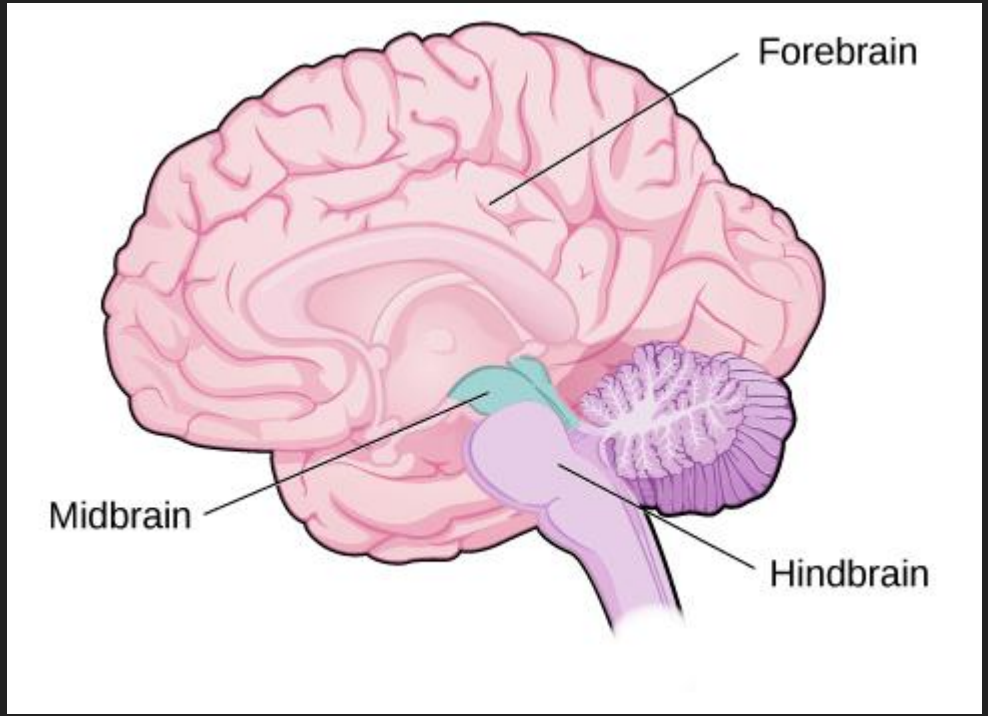
Ventral root: relays motor information (front)



# Structures and Functions of the Brain

# 3 Brain Regions

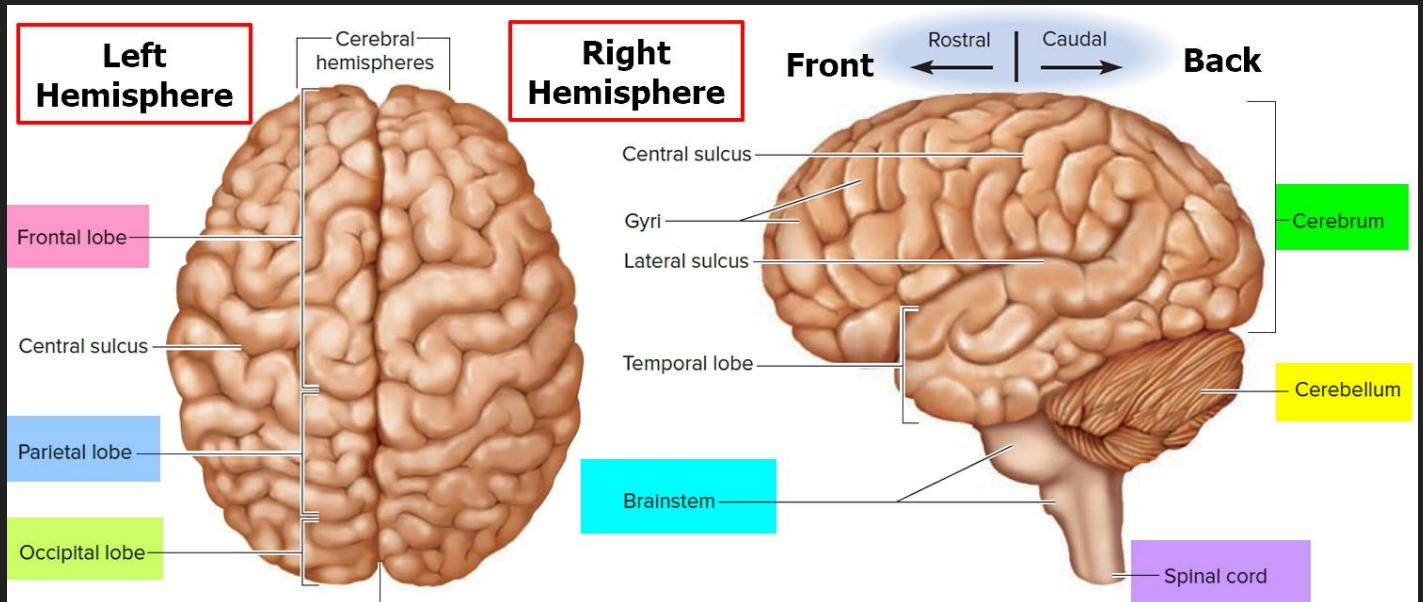
1. Forebrain
2. Midbrain
3. Hindbrain



# Forebrain

Cerebrum: largest part of the forebrain

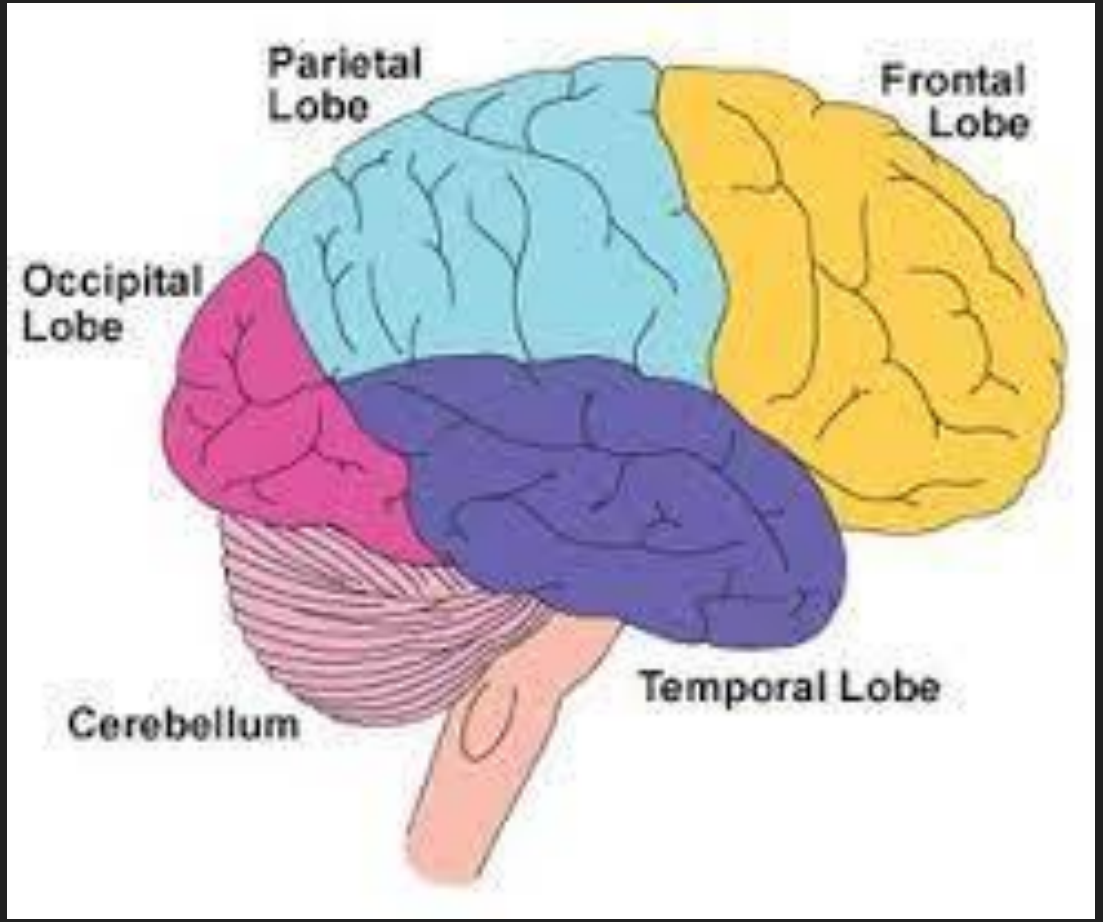
- Composed of the right and left hemispheres
- Cerebral cortex: Outermost surface of cerebrum
  - Consists of grey matter + fissures (deep folds)



# Hemisphere Organization

Each hemisphere is composed of 4 regions:

1. Front lobe
2. Temporal lobe
3. Parietal lobe
4. Occipital lobe

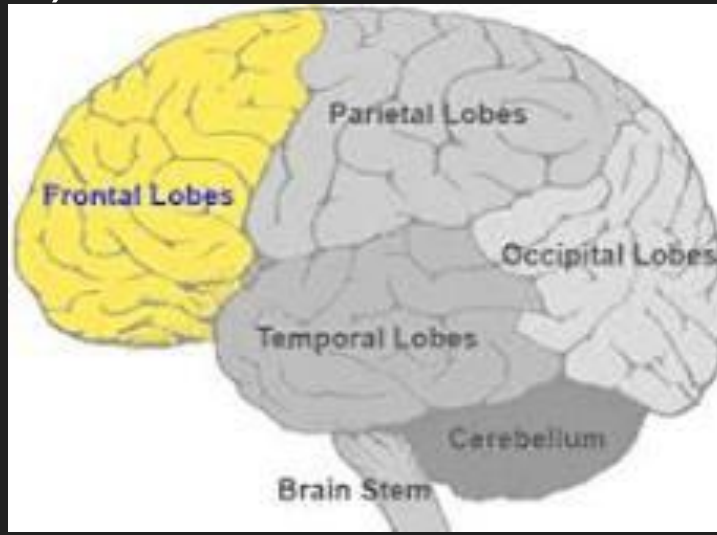

Parietal Lobe
Frontal Lobe
Occipital Lobe
Temporal Lobe
Cerebellum

Frontal Lobe (“Decision-maker”)

Functions:

1. Voluntary motor function (e.g. walking + speech)
2. Intellectual activities/personality

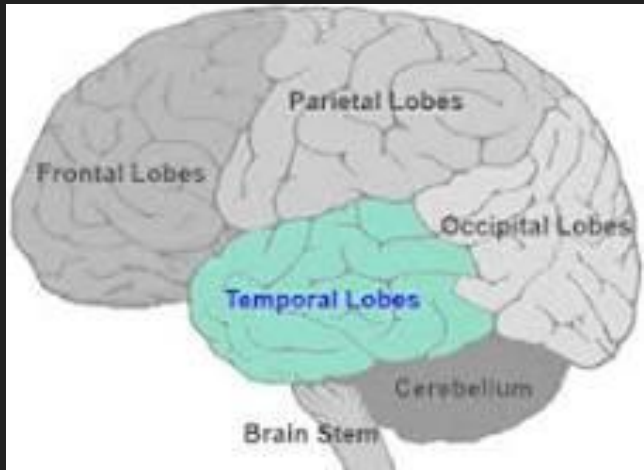
Contains: Primary Motor Cortex (posterior)



# Temporal Lobe

## Function:

1. Smell via “olfactory bulbs”(1 in each Hemisphere)
2. Memory + Sensory Processing
3. Vision + Hearing



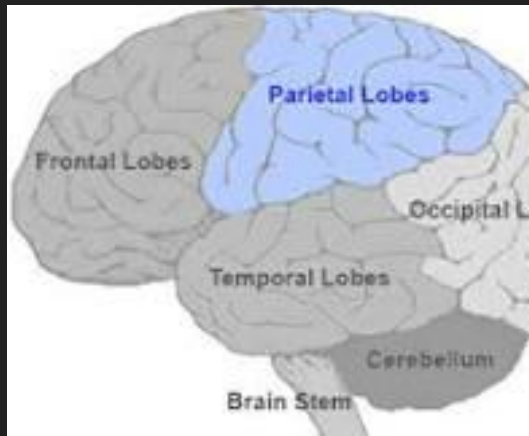
# Parietal Lobe

## Function:

1. Body Senses (touch, temperature, pain)
2. Emotion Perceptions
3. Interpret speech

Contains: Primary Sensory Cortex

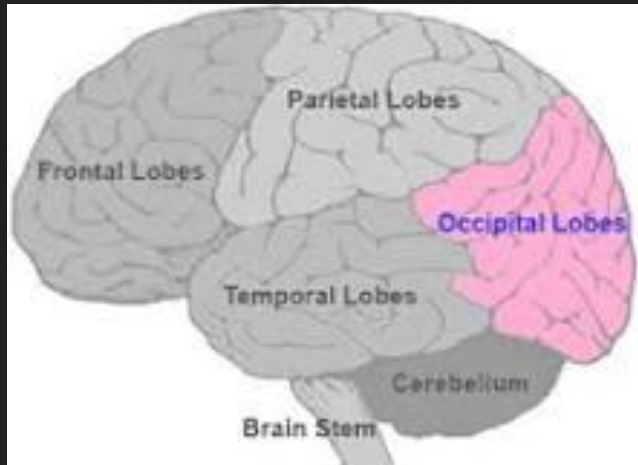
(anterior)



# Occipital Lobe

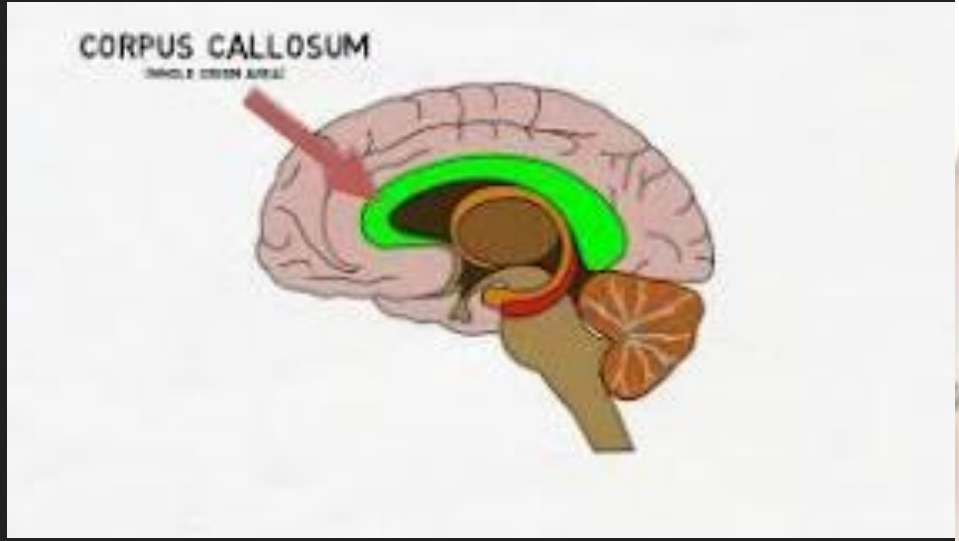
## Functions:

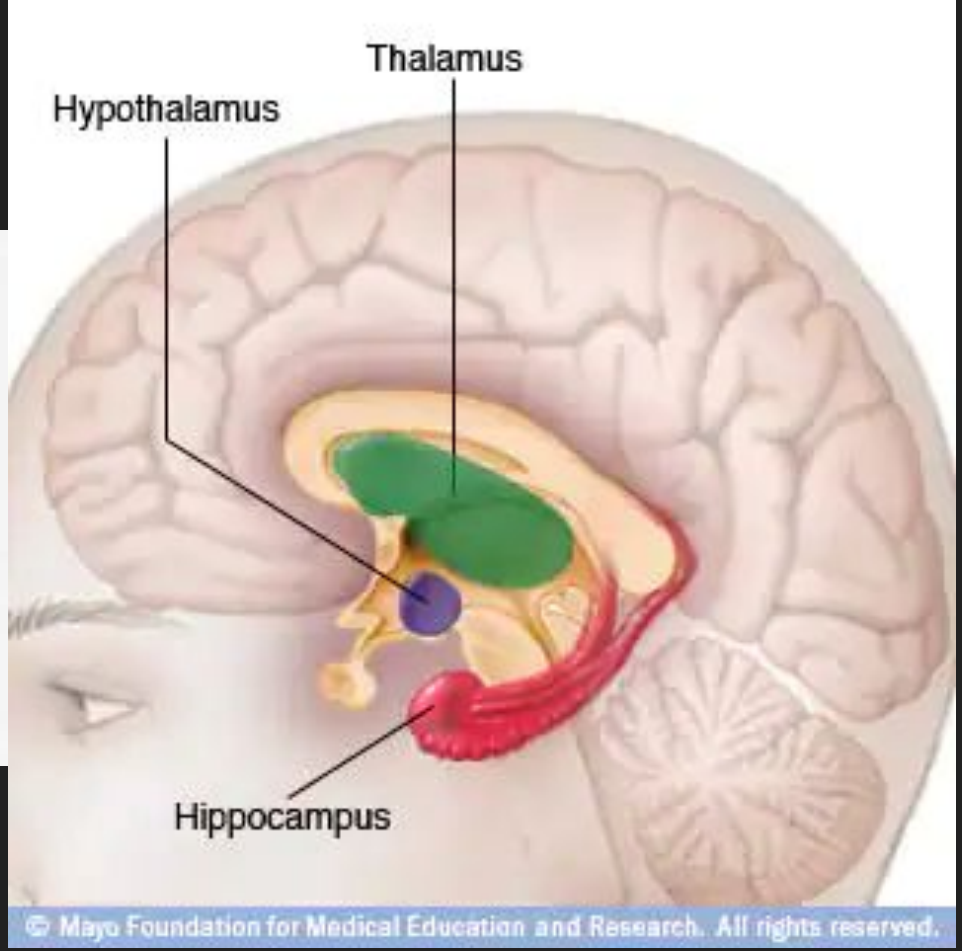
1. Vision (see + interpret)



# Other Forebrain structures

1. Corpus Callosum: nerve tract joining the hemispheres (communication bridge)
2. Thalamus: relay station for sensory information
3. Hypothalamus: coordinates most nerve and hormone functions to maintain homeostasis (i.e. internal equilibrium) *Hypothalamus-pituitary complex* (C15)


CORPUS CALLOSUM


Thalamus
Hypothalamus
Hippocampus
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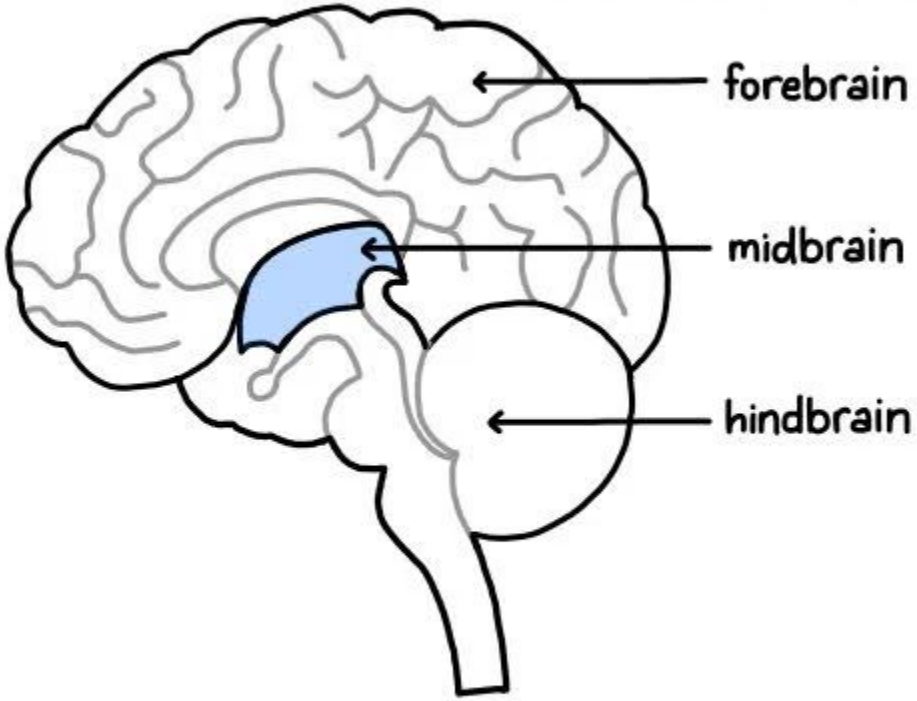
# Midbrain

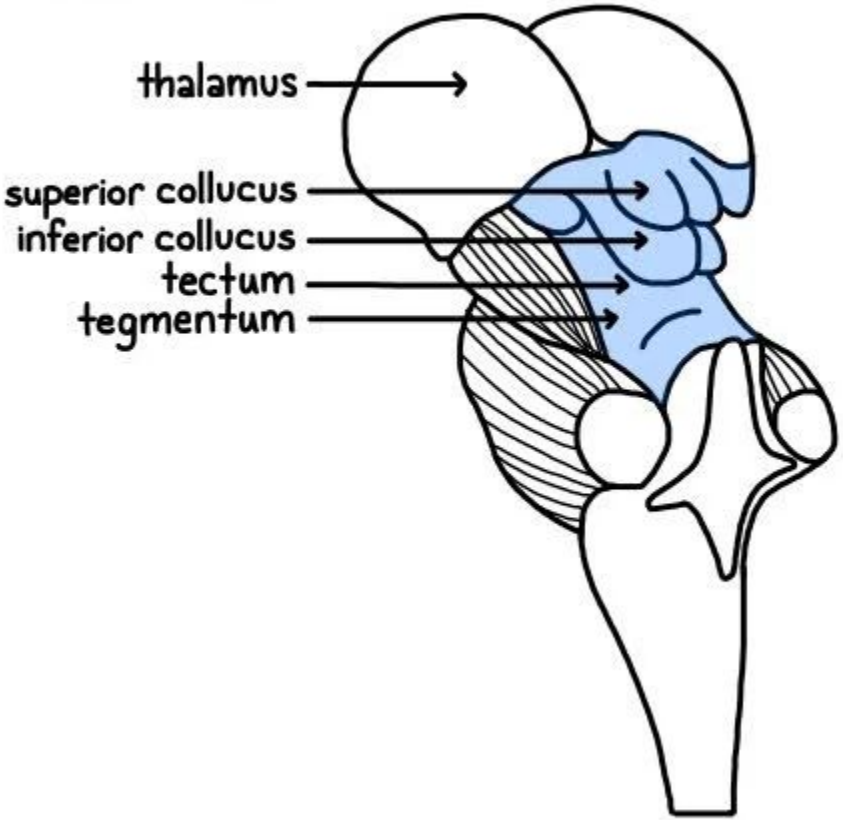
Location: below the thalamus

Composition: 4 grey matter spheres

Function: eye and ear reflex relay center

# MIDBRAIN STRUCTURES



# Hindbrain Structures

1. Cerebellum: large hindbrain structure

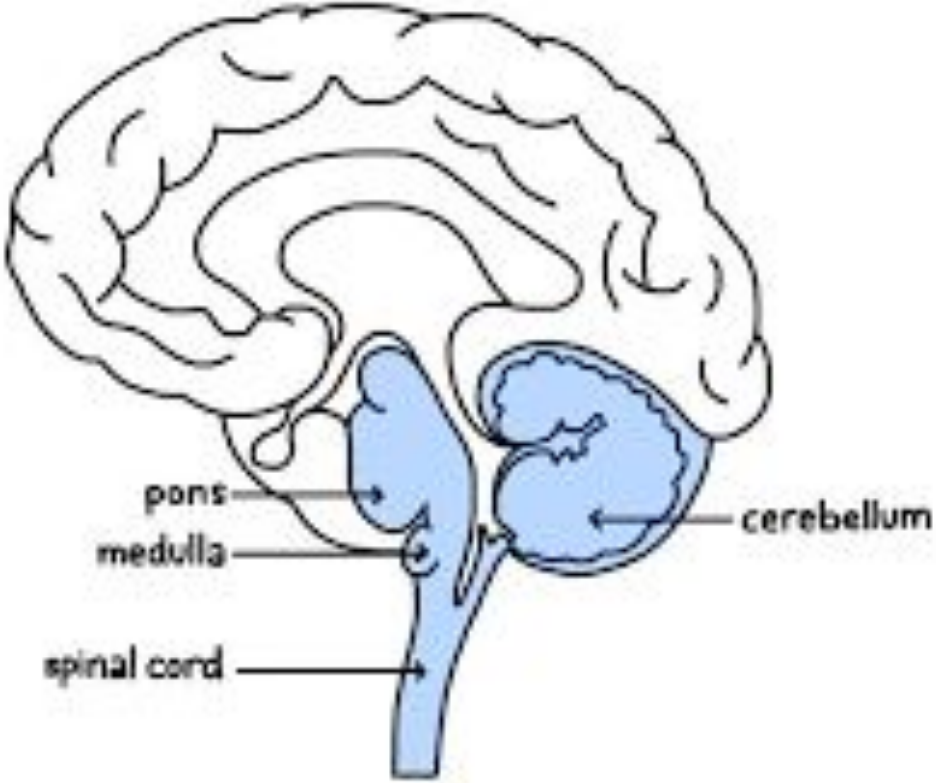
Function: limb movements, balance, and muscle tone

1. Medulla Oblongata (MO): connects brain and spinal cord
- Serves as the connection bw CNS and PNS

Function: autonomic nervous system control (e.g. breathing, blood vessel diameter)

1. Pons: Relay station connecting the cerebellum and MO

# HINDBRAIN STRUCTURES



PNS

# Review

PNS is composed of

1. Sensory-somatic NS (voluntary)
    - Detects EXTERNAL sensory information
    - Produces Voluntary Responses (i.e. muscle movements)
        - Exception: reflex arcs
2. Autonomic NS (involuntary)
    - Detects INTERNAL sensory information
    - Produces Involuntary Responses (smooth muscle, cardiac muscle, internal organs and glands)

Divided into 2 systems

- Sympathetic NS (stress, fight-flight)
- Parasympathetic NS (rest, relaxed)

Both systems are composed of sensory and motor neurons

# Sensory-Somatic NS *NOT IMPORTANT, READ NOT MEMORIZE*

Consists of:

1. 12 Cranial Nerves (Brain nerves)

a. Function: controls

   i. 4 senses (taste,smell, hearing, vision)

   ii. Balance

   iii. Facial and tongue movements

   iv. Head and neck muscles

1. 31 pairs of spinal nerves

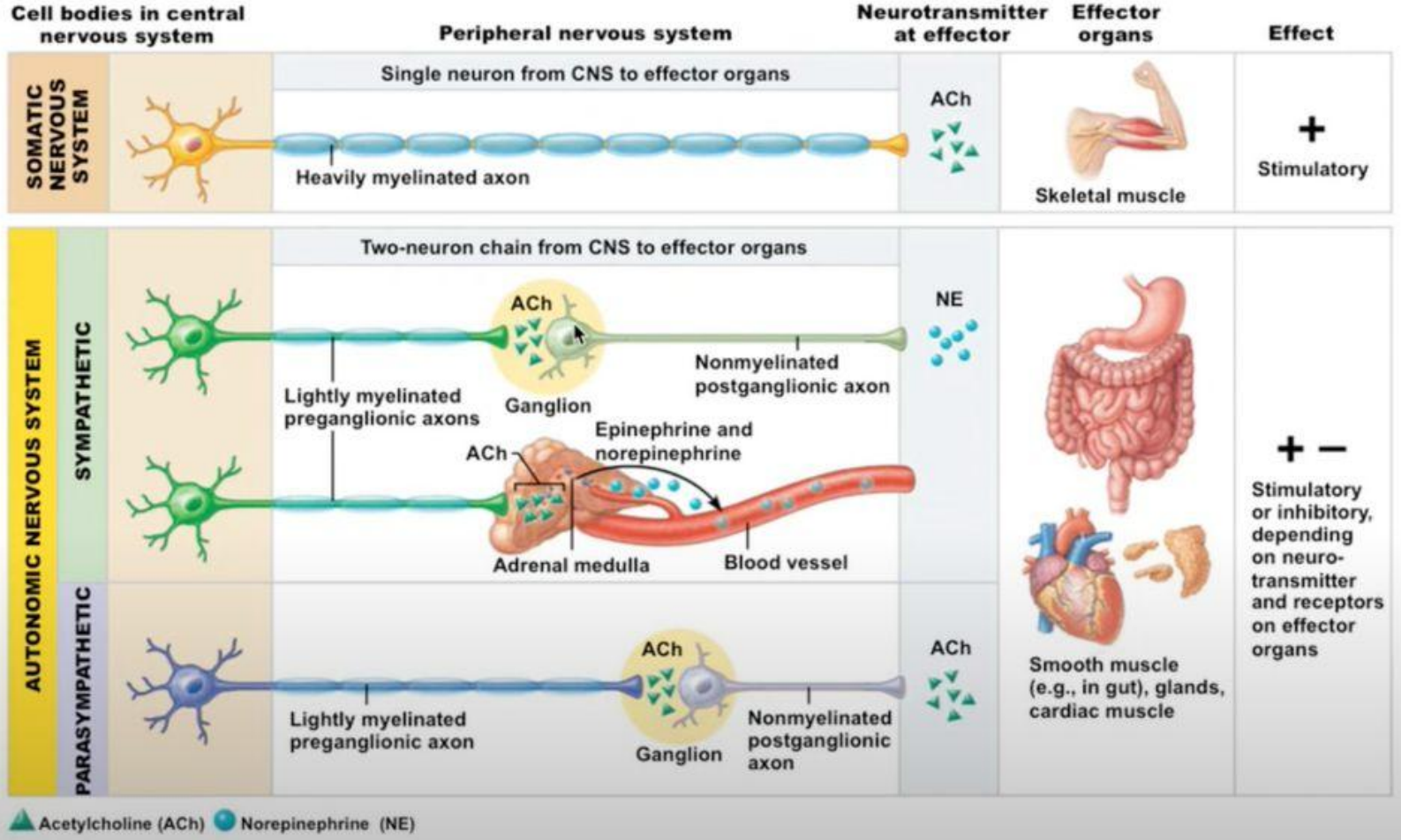
Function: all skeletal muscles below the neck

# Autonomic NS Anatomical Differences

The autonomic NS differs anatomically to the somatic NS

The autonomic NS consists of 2 motor neurons.

1) **Pre**ganglionic Neurons
    a) Runs from CNS to post ganglionic neuron
2) **Post**ganglionic Neurons
    a) Runs to target effector (organ, muscle or gland)


Cell bodies in central nervous system
Peripheral nervous system
Neurotransmitter at effector
Effector organs
Effect
SOMATIC NERVOUS SYSTEM
Single neuron from CNS to effector organs
Heavily myelinated axon
ACh
Skeletal muscle
+
Stimulatory
AUTONOMIC NERVOUS SYSTEM
SYMPATHETIC
Two-neuron chain from CNS to effector organs
ACh
Ganglion
Lightly myelinated preganglionic axons
Nonmyelinated postganglionic axon
NE
Epinephrine and norepinephrine
ACh
Adrenal medulla
Blood vessel
PARASYMPATHETIC
ACh
Lightly myelinated preganglionic axon
Ganglion
Nonmyelinated postganglionic axon
ACh
Smooth muscle (e.g., in gut), glands, cardiac muscle
+ −
Stimulatory or inhibitory, depending on neuro-transmitter and receptors on effector organs
Acetylcholine (ACh)
Norepinephrine (NE)

# Anatomical Differences in ANS

## Sympathetic NS

- Short preganglionic neuron, long postganglionic neuron
  - Postganglionic neuron releases norepinephrine.

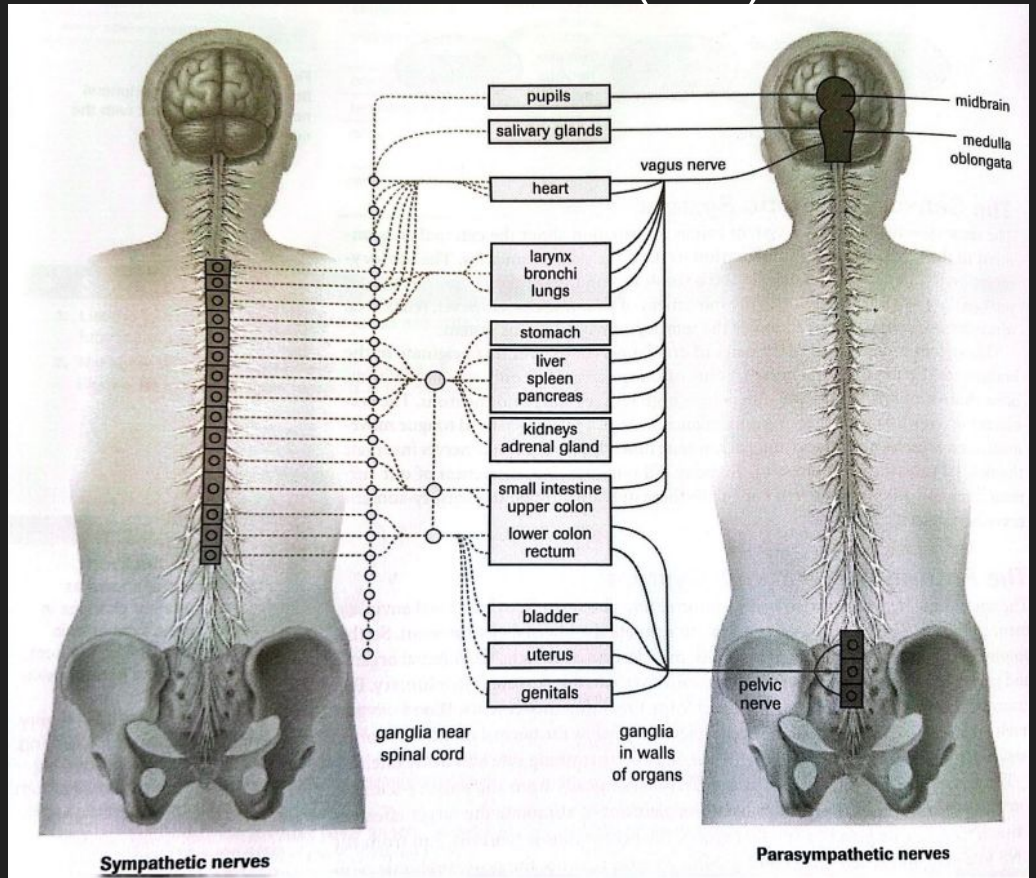
## Parasympathetic NS

- Long preganglionic neuron, short postganglionic neuron
  - Postganglionic neuron releases acetylcholine and nitric oxide

Note: both preganglionic neurons release acetylcholine

# Sympathetic NS innervation *Read NOT Memorize*

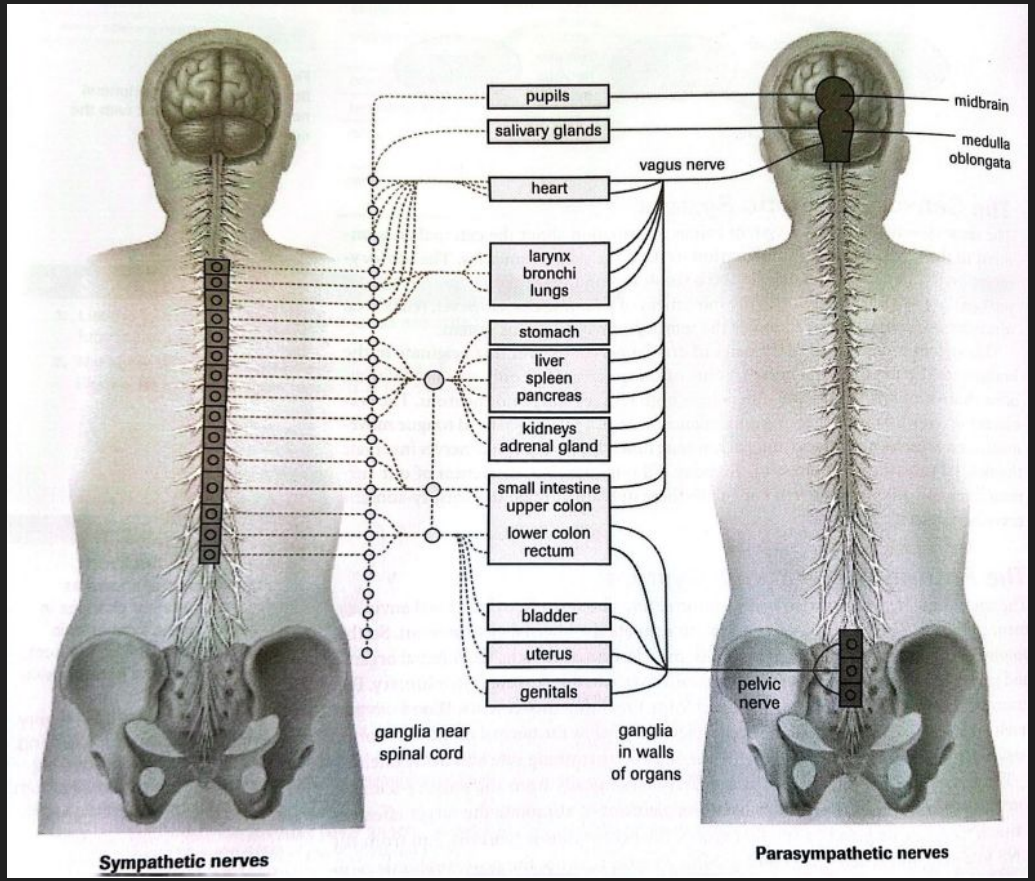
Sympathetic nerves come from thoracic (ribs) and lumbar (back region)



# Parasympathetic NS innervation *Read NOT Memorize*

Nerves come directly from:

1. Brain
2. Cervical (neck)
3. Caudal (tailbone)



# Vagus (“wandering”) Nerve

Important Cranial Nerve in the ParaNS (plays a very large role)

- Involved in innervation of the heart, lung bronchi, liver, pancreas, and the digestive tract.

# Sympathetic vs Parasympathetic Response *Rationalize*

| Organ | Sympathetic | Parasympathetic |
|---|---|---|
| heart | increases heart rate | decreases heart rate |
| digestive tract | decreases peristalsis | increases peristalsis |
| liver | increases the release of glucose | stores glucose |
| eyes | dilates pupils | constricts pupils |
| bladder | relaxes sphincter | contracts sphincter |
| skin | increases blood flow | decreases blood flow |
| adrenal gland | causes release of epinephrine | no effect |

# Summary of Chapter 14

Mr Shousha

9 Receptor Types *Read NOT memorize*

- Taste and smell (respond to chemical stimulus)
- Pressure, balance and proprioception (mechanical stimulus)
  - Pressure (skin contact)
  - Balance (maintain posture during movement)
  - Proprioception (awareness of limb positions)
- Audio (sound stimulus)
- Visual (light)
- Thermoreceptor (temperature changes)
- Nocioreceptors (detect pain)

## Detection of Sensation

All sensation is detected by our brains and NOT our receptors.

- The job of receptors is to convert one energy form to another (e.g. eye receptors = light → electrical (AP))

## Sensory Adaptation

- Receptor becomes less sensitive to stimuli once stimuli is repeated eventually until stops firing completely.

Taste Receptors *Read NOT Memorize*

- Helps differentiate edible vs inedible food.
- Taste buds detect the dissolved chemicals on the tongue.

Detects 5 Types of taste:

1. Sour, Sweet, Salt, Bitter, Savoury (umami)

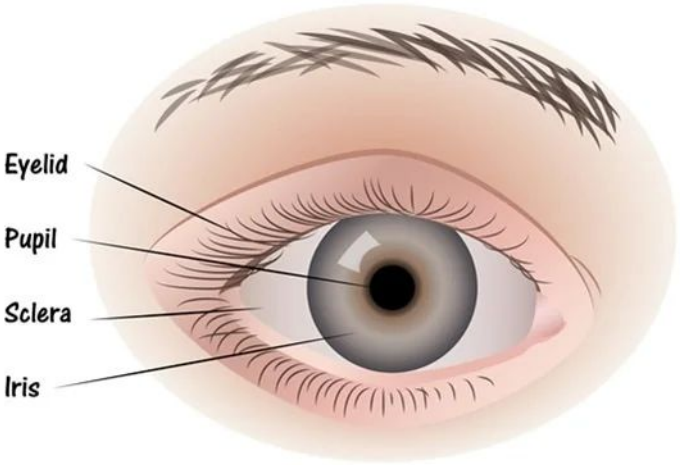
{Note}
We experience our food through the type of taste, smell and chemical irritation/mouth feel.

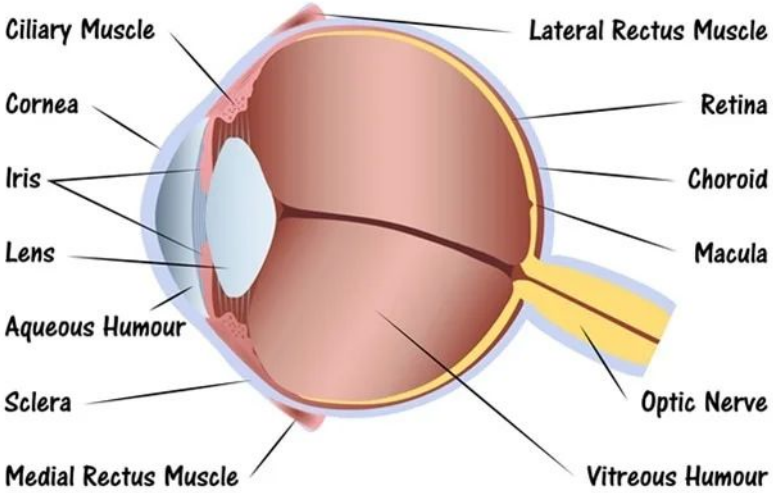
1. taste receptors detect dissolved chemicals
2. smell receptors detect airborne chemicals.

# 14.2: Structures of the Eyes

The eye of is comprised of 3 layers

1. Sclera (outer layer)
2. Choroid layer (middle layer)
3. Retina (inner layer)


Eyelid
Pupil
Sclera
Iris


Ciliary Muscle
Cornea
Iris
Lens
Aqueous Humour
Sclera
Medial Rectus Muscle
Lateral Rectus Muscle
Retina
Choroid
Macula
Optic Nerve
Vitreous Humour

Outer layer:

Sclera: white outer layer that maintains eye shape

Cornea: clear coat in front of sclera that bends light into the eye

Aqueous Humor: watery liquid behind the cornea, Nutrient/Oxygen supply (no blood vessels in the cornea)

Middle Layer:

Choroid Layer: middle layer with blood vessels supplying the retina with nutrients and oxygen

Iris: coloured part of eye that regulates amount of light entering

Pupil: eye hole that allows light to enter

Lens: focuses light on retina

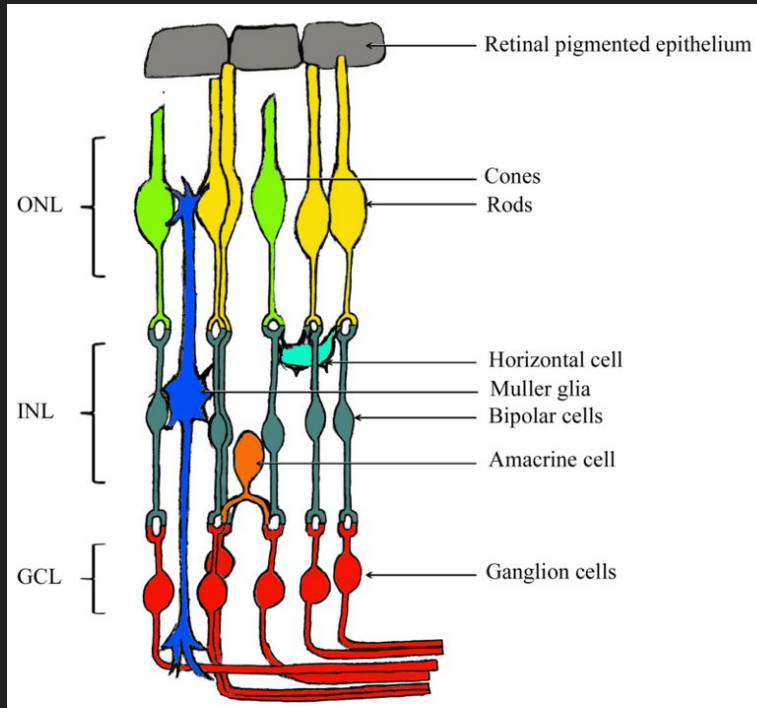
Ciliary Muscles: regulates lens shape

Vitreous Humor: maintains eye shape + permits light to the retina

Retina: Innermost section of the eye containing photoreceptors (cone and rods) to capture light into the eye

Retina Organization (4 layers of tissue)

1. Pigmented Epithelium
2. Light-sensitive receptors
    - (photoreceptors)
3. Bipolar cells
4. Cells of the optic nerve



Other Retina Structures:

1. Light-Sensitive Receptors

- Rods: responds to Low intensity light (B/W)
- Cones: responds to High intensity light (colour)

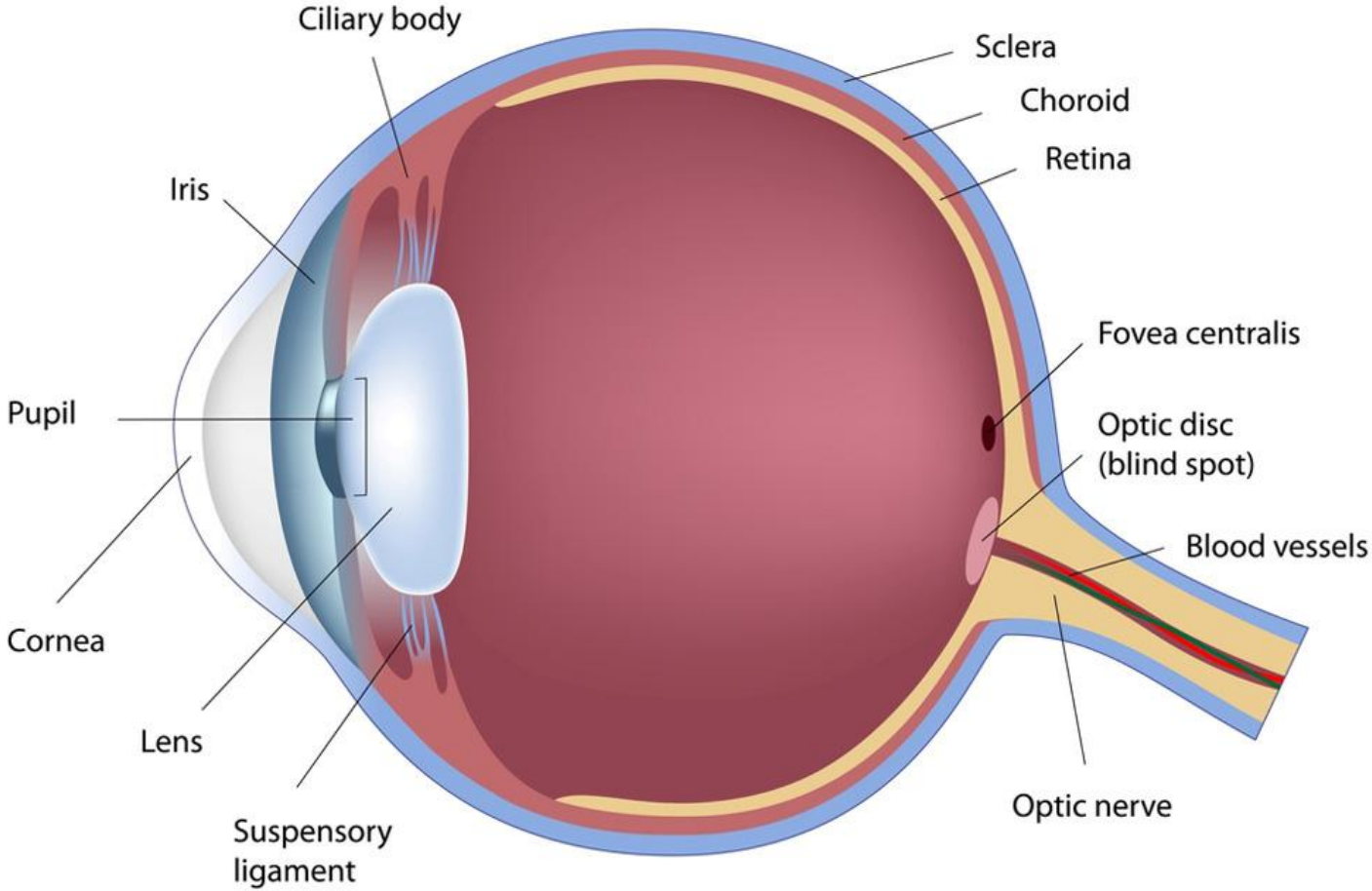
**Rods and cones are unevenly distributed around the eye**

2. Fovea Centralis

- Small depression on the retina
- Contains cones only (rods surround) *Most light-sensitive*

3. Blind spot

- Point where optic nerve connects with retina = no vision
  - No photoreceptors


Ciliary body
Sclera
Choroid
Retina
Iris
Fovea centralis
Pupil
Optic disc
(blind spot)
Blood vessels
Cornea
Lens
Suspensory
ligament
Optic nerve

## Chemistry of Vision: Using Roads

Rods with "rhodopsin." (light-sensitive pigment)

- Made of retinene (vitamin A) + opsin (large protein).

Light → rhodopsin → Vit. A + opsin → AP → rhodopsin reforms*REPEAT*

---

## Colour Perception: job of cones

Each cone can see 1 of 3 primary colours: red, blue, green

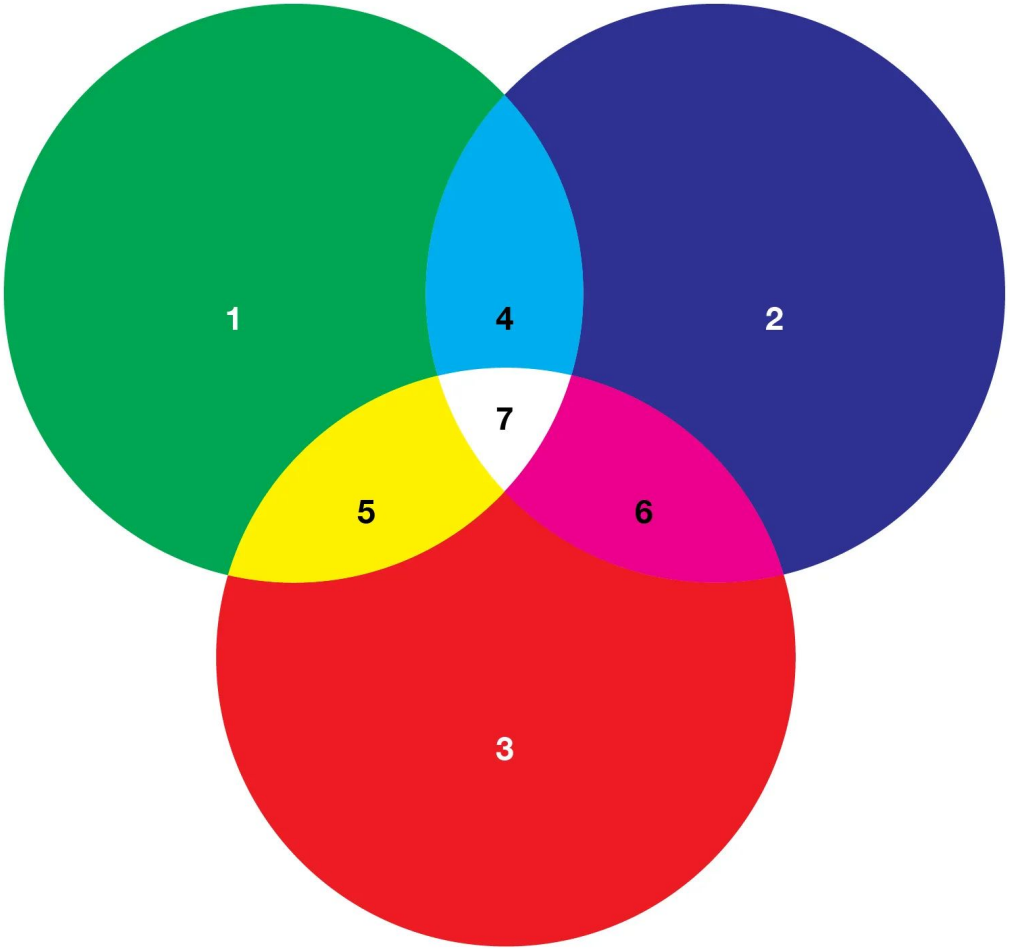
Secondary colours come from combining primary colours

- Magenta, yellow, cyan

Colour blindness: when one or more cones are deficient

E.g. red-green colourblindness ( red-pigmented cones don't work)

## Primary Colors of Light



# Light pathway into the eye

1. Light hits the cornea
2. Light bent/refracting towards the pupil
3. Light passes through the lens where the light is refracted on a focal point on the retina
4. Image on the retina is inverted.

# Accommodation: Ciliary Muscles

Adjustments to eye **lens thickness** and **pupil size** for viewing near and distant objects.

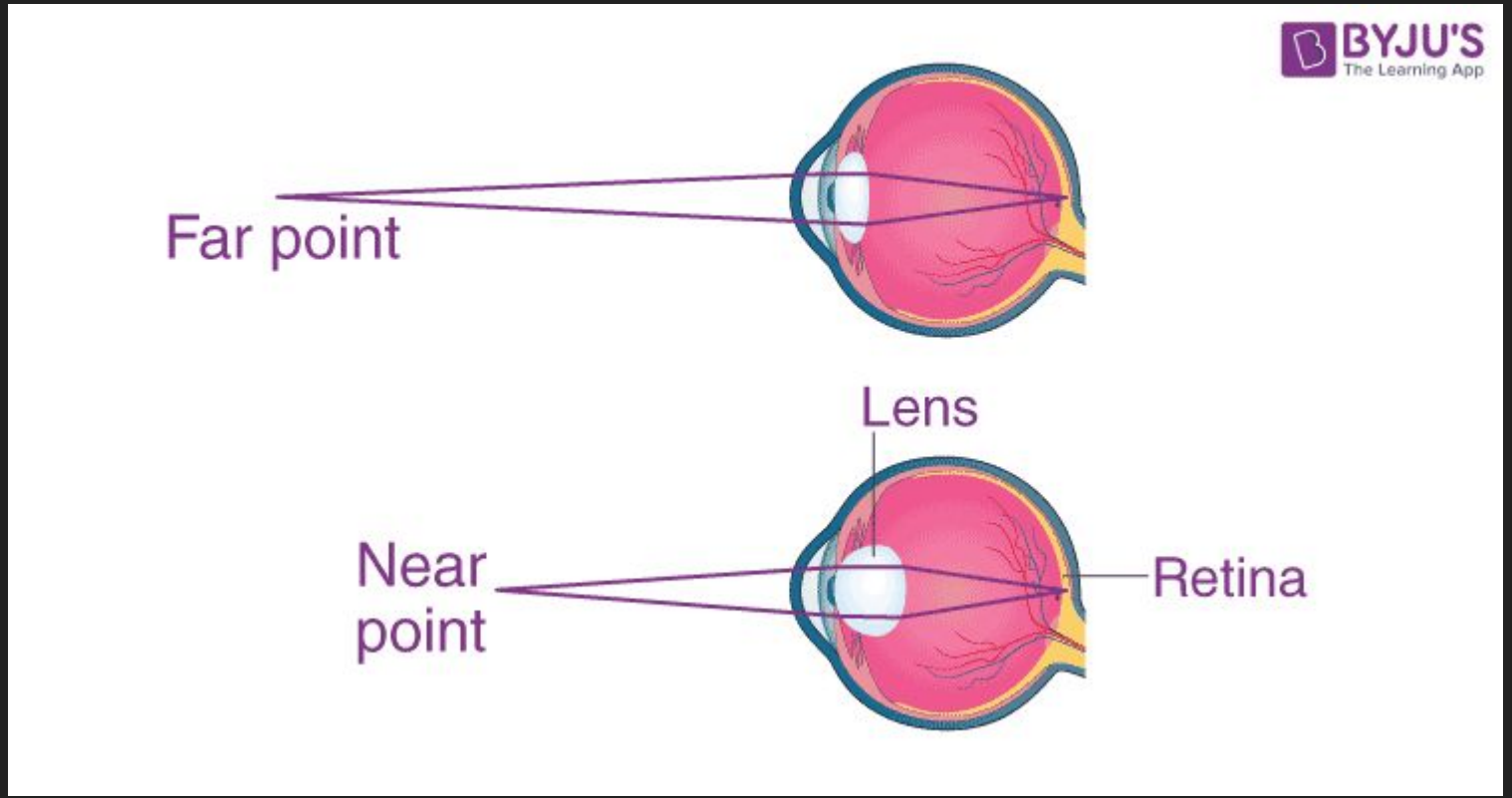
For near viewings:

Ciliary muscles contract = lens becomes thicker = more bending

For far viewings:

Ciliary muscles relax = lens becomes thinner = less bending

Note: accomodation diminishes with age


BYJU'S
The Learning App
Far point
Lens
Near
point
Retina

# Secondary Accommodation: Pupils

Near viewings: Pupils constrict = more detailed image

Far viewings: Pupils dilate = see more light.

# Vision Defects *memorize*

1. Glaucoma:build up of aqueous humor (poor drainage)
    a. Untreated = fluid + pressure build up = optic nerve cells die = vision loss
2. Cataract: lens or cornea become opaque (no light entering the eye)
3. Astigmatism: vision defect caused by irregularly shaped lens or cornea.

4. Nearsightedness (myopia):

- Eyeball is too long
- Lens can’t flatten enough = image in front of the retina
- Corrected with concave lens glasses

5. Farsightedness (hyperopia):

- Eyeball is too short
- Image is projected behind the retina
- Corrected with convex lens glasses

# Glaucoma VS Cataracts

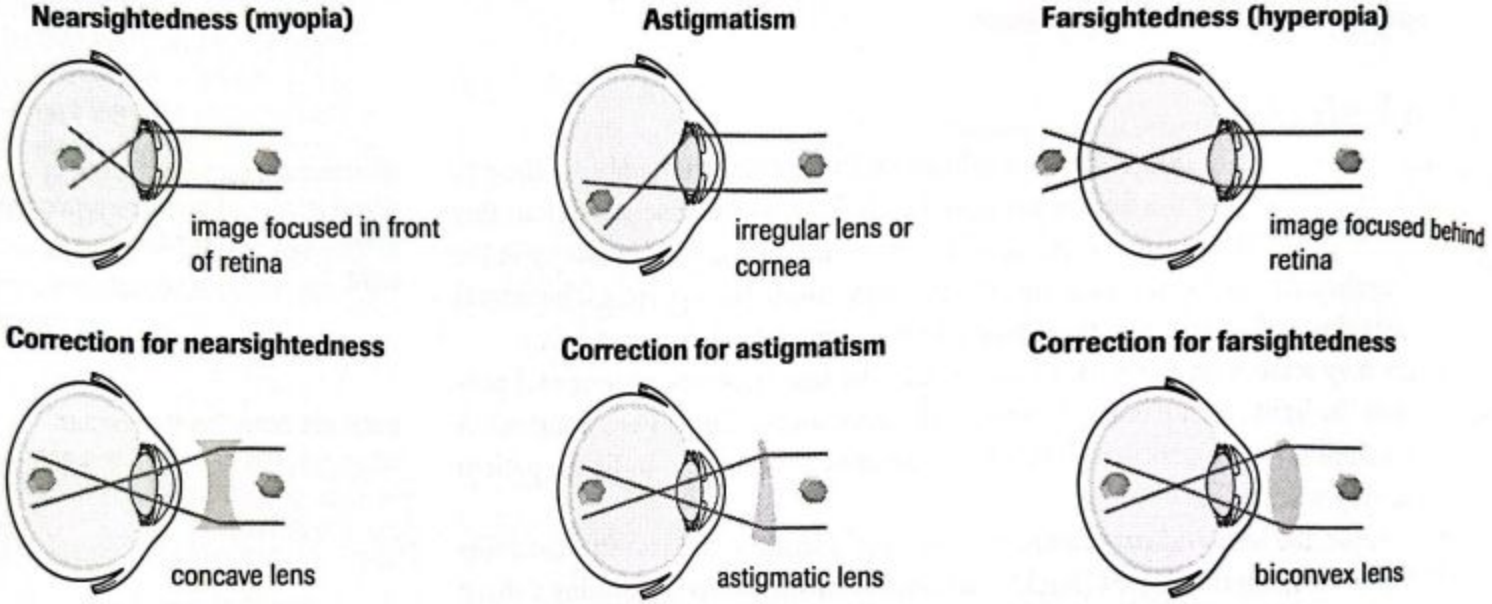
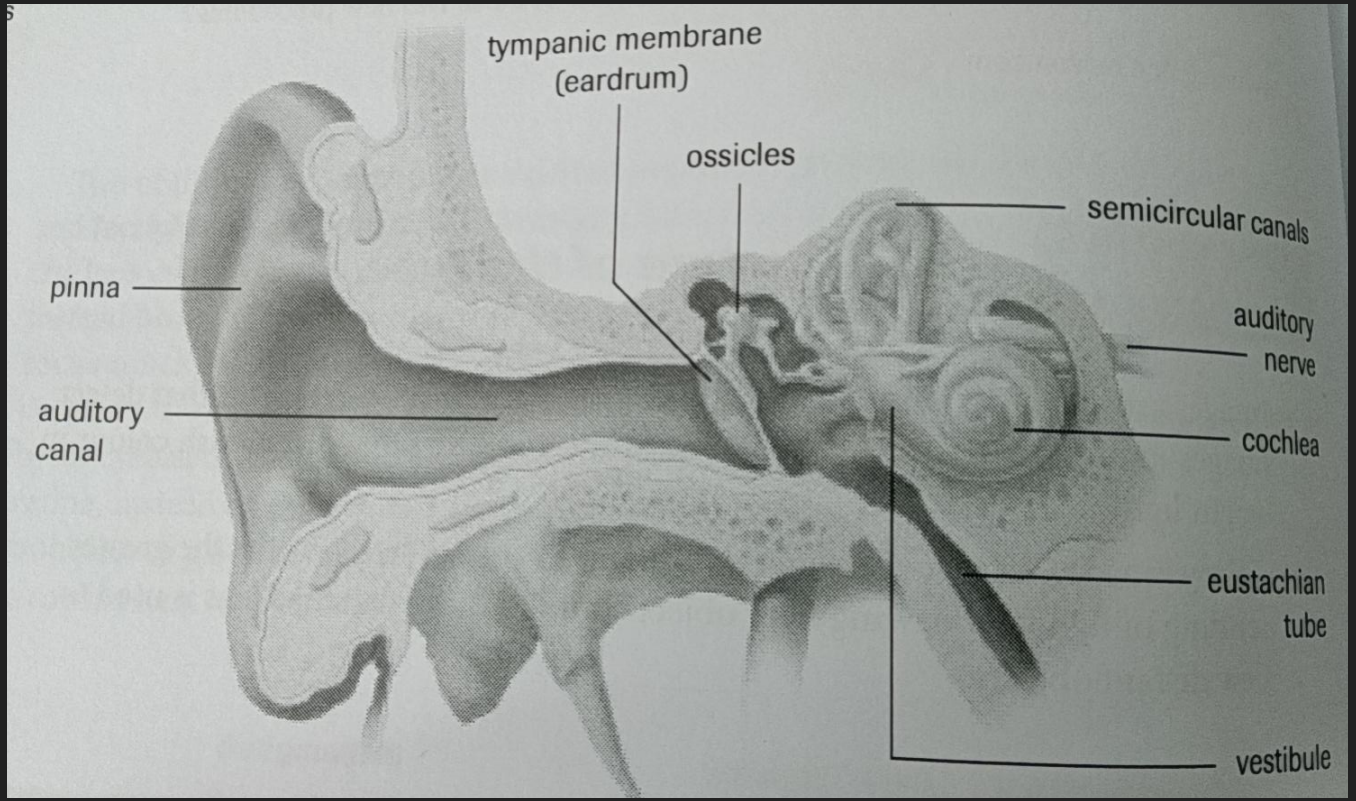



**Figure 7**
Visual defects can be improved with corrective lenses.

# 14.3: Hearing and Equilibrium

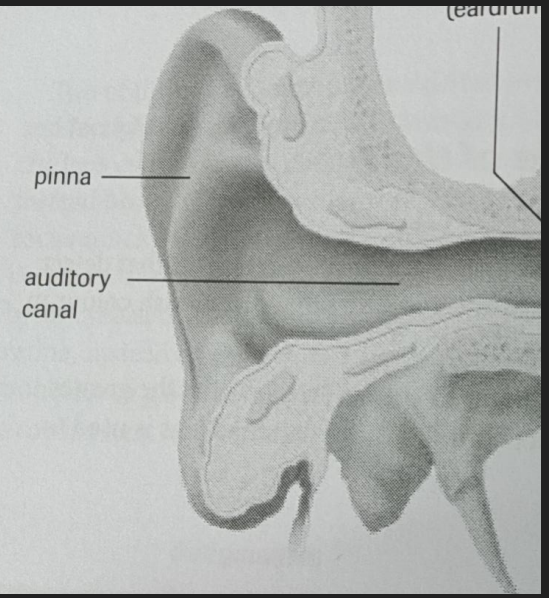
# Divisions of the Ear

1. Outer ear
2. Middle ear
3. Inner ear



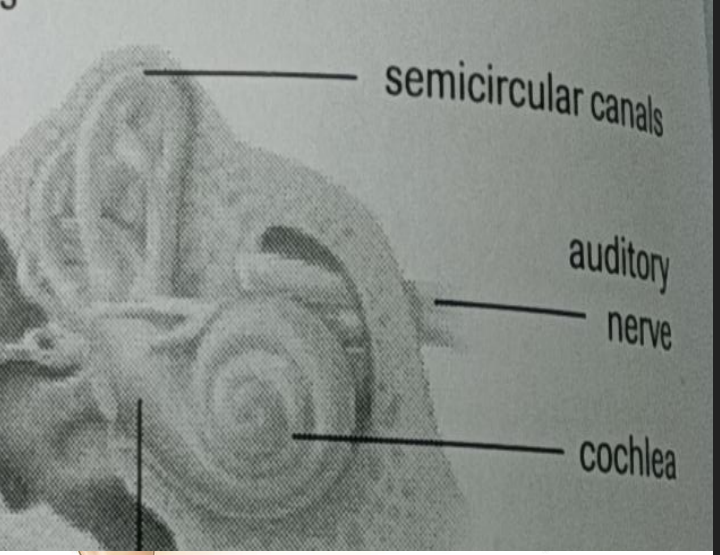
# Outer ear

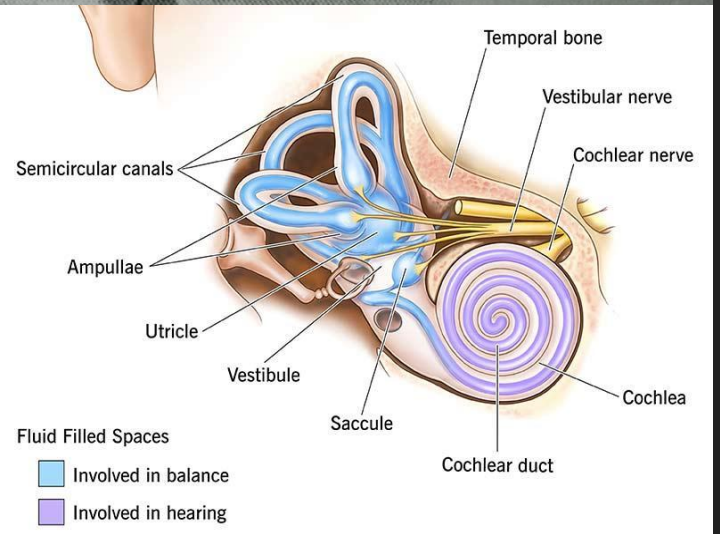
1. Outer ear
    a. Pinna (sound collection)
    b. Auditory canal (carries sound)
        i. Protects ear from foreign particles via ear wax



# 2. Middle ear


a. Tympanic membrane/eardrum (covers round and oval windows)
b. Ossicles (3 bones)
    i. Transfer + amplify sound
    ii. Malleus (hammer), incus (anvil), stapes (stirrup)
c. Oval window
d. Eustachian tube (connected to the mouth + nose)
    i. Equalization air pressure
    ii. Drain excess fluid



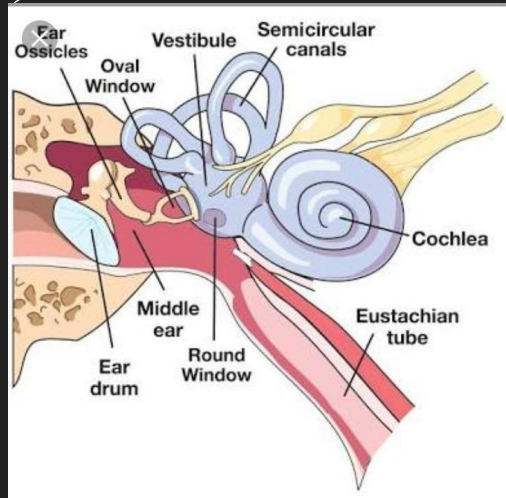

1. Inner ear
    a. Vestibule (balance)
        i. Contains the utricle and saccule (head position)
    b. Semicircular canals (balance)
        i. 3 canals (fluid movement = body movement)
            - Containing an ampula
                - contains a capula
    c. Cochlea (hearing) (hair cells convert sound → NI)
        i. Contains the organ of corti

- Sound receptors detect vibrations from basilar membrane (B.M.)
- Fluid moves hair cells on B.M. = stimulate neurons

# Hearing and Sound

# Movement of Sound Steps

1. Sound collection (outer ear)
2. Sound waves push on the tympanic membrane
3. Vibration moves ossicles (3x)
4. Ossicles amplify onto the oval window
5. Oval window (pushed IN) + round window (pushed OUT)
6. Sound waves → fluid waves → electrical (NI) → CNS (temporal)***



## Middle Ear Protection Reflex:

Excessive Noise = Muscles (2) contract = Malleus movement and intensity is restricted + Stapes pulled away from oval window.

---

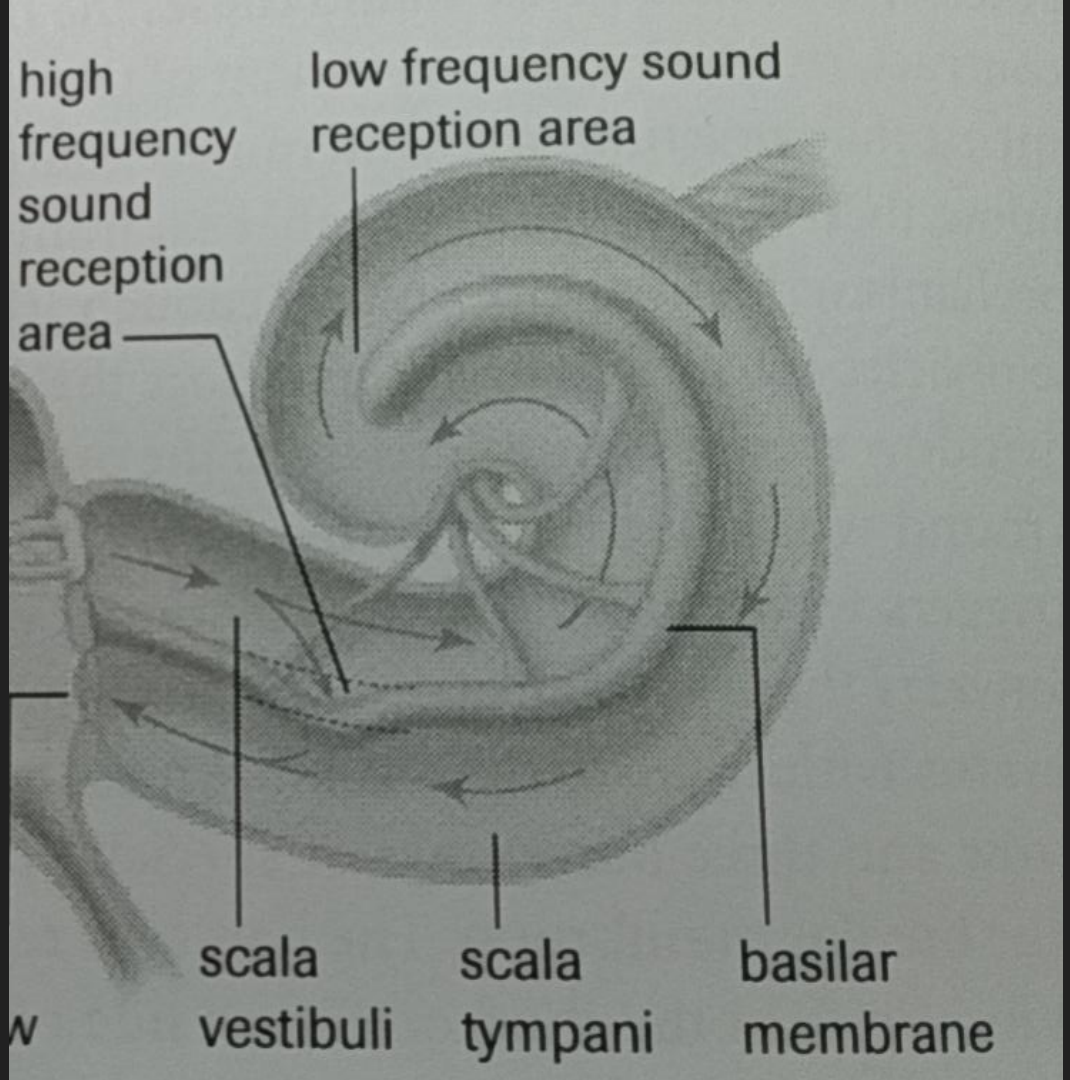
## Detecting Sound and Pitch:

High Frequency Sound = registered as high pitch

- Detected by basilar membrane (narrow + stiff)
  - Contains enough energy to move a stiff membrane
  - Closer to oval window

Low Frequency Sound

- Detected by sections farther down the cochlea (more flexible)


high frequency sound reception area
low frequency sound reception area
w
scala vestibuli
scala tympani
basilar membrane

# Balance: 2 Types

1. Static Equilibrium: equilibrium involving 1D movement (e.g. vertical or horizontal)
    - Head movement monitored by saccule (vertical) and utricle (horizontal) in the vestibule
        - Saccules and utricles are fluid filled + contain cilia + contain otoliths (calcium carbonate stones that move the hair cells)
2. Dynamic equilibrium: equilibrium involving more than 1 plane (2D+)
    - Balance during motion is monitored by semicircular canal

## Head Movement and Static Equilibrium

- Head movement = otoliths slide up and down = jelly membrane moves = cilia moves = stimulates sensory nerves = relay to CNS (cerebellum)

## Dynamic Equilibrium

- Rotational movement/stimuli = movement in the fluid of the semicircular canals = bends hair cells in capulla = trigger sensory nerve = CNS (cerebellum)

# Types of Hearing Loss *Read NOT MEMORIZE AT ALL*

- Conductive:
  a. Sounds waves do NOT reach the inner ear

Possible causes: Wax buildup, eardrum damage, ear infection.

Corrected with surgery

- Sensorineural:
  b. Auditory nerve or cochlear hair cell damage

Possible causes: Age, exposure to loud noise, head trauma.

# Treatments for Hearing Loss

1. Hearing Aids: amplifies noise and transmits it directly on the eardrum
2. Cochlear Implants: transmits sound information directly to the auditory nerve via electrical information.

# Summary of Chapter 15

Mr Shousha

**Homeostasis**: maintenance of a constant internal environment

- **Dynamic equilibrium**: stability within a limited range of change (i.e. +- 37 C, +-0.1% glucose, +- 7.35 pH)

---

**Homeostatic Control**:

Receptor → coordinating center* → effector

*hypothalamus/pituitary complex

E.g. High $CO_2$ levels in the blood → relays information to CC → send nerve impulse to breathing muscles + expand lungs → increase breathing rate → decreases $CO_2$ levels.

# Homoeostasis/Regulation through Feedback Loops (+-)

Positive feedback: small change results in an increase of change

- Moving further away from homeostasis
  - E.g. parturition

Negative feedback: change that returns back to original state

- Returning to homeostasis
  - E.g blood and osmotic pressure regulation

Hormones: chemicals produced by cells that **alter other** cells

- Function: regulate body (increase or decrease a bodily response)
- Endocrine hormones (hormones made by endocrine cells/glands)
  - Hypothalamus, pituitary gland, thyroid, parathyroid, teses, and ovaries (endocrine glands)

---

Hormones can be classified by their:

1. Active site
   a. *Target*: act on one specific site (e.g. gastrin + stomach)
   b. Non-target: act on multiple sites of the body (e.g. insulin and hGH)
2. Chemical nature/composition
   a. Water-soluble: act via receptors OUTSIDE the cell membrane
   b. Fat-soluble (i.e. steroids): act via receptors INSIDE the cell mem.

# Chemical Controls

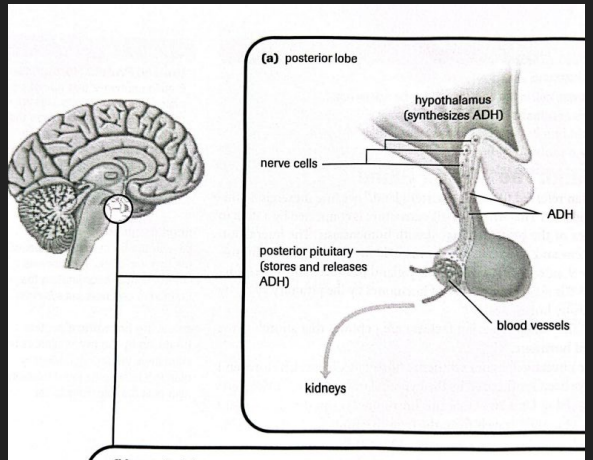
Body regulates endocrine and nervous functions through several mechanisms

1. Hypothalamus/pituitary complex
    a. Both structures are involved in production and secretion of hormones
2. Receptor Location
    a. Receptors are only present at target sites
3. Receptor Abundance
    a. Receptors are more present at certain locations of the body

# Hypothalamus-pituitary complex

1. **Pituitary gland** involved in producing and storing hormones
2. **Hypothalamus** involved in stimulating the release of hormones from the pituitary gland via nerve impulses and releasing hormones/factors*
   a. Also produces ADH/vasopressin and oxytocin
   b. Also releases inhibiting factors (inhibits the anterior pituitary gland)

**Releasing hormones/factors**: peptides that trigger the release of stored hormones



# Pituitary Gland “Master Gland”

Composed of

1. Anterior pituitary gland: produces and stores hormones
2. Posterior pituitary gland: stores hormones made by hypothalamus

**Table 1** Pituitary Hormones

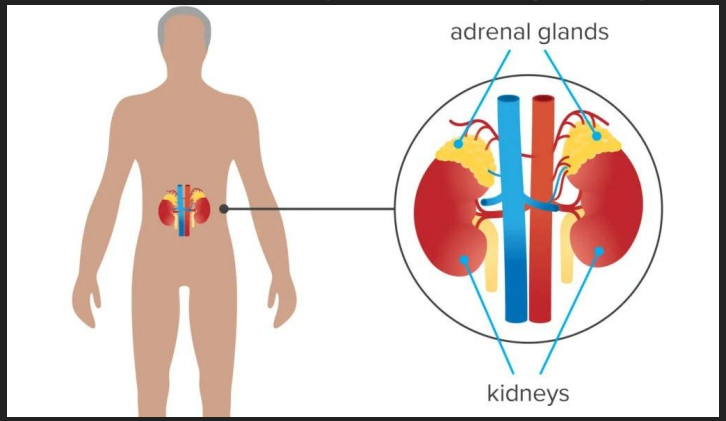
| Hormone | Target |
|---|---|
| ***Anterior lobe*** | |
| thyroid-stimulating hormone (TSH) | thyroid gland |
| adrenocorticotropic hormone (ACTH) | adrenal cortex |
| human growth hormone (hGH) | most cells |
| follicle-stimulating hormone (FSH) | ovaries, testes |
| luteinizing hormone (LH) | ovaries, testes |
| prolactin (PRL) | mammary glands |
| melanocyte-stimulating hormone (MSH) | melanocytes in skin |
| ***Posterior lobe*** | |
| oxytocin | uterus, mammary glands |
| antidiuretic hormone (ADH) | kidneys |

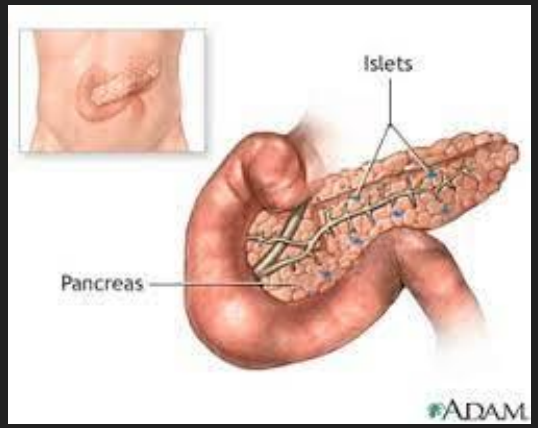
# Glucose Control

# Blood Sugar Endocrine glands

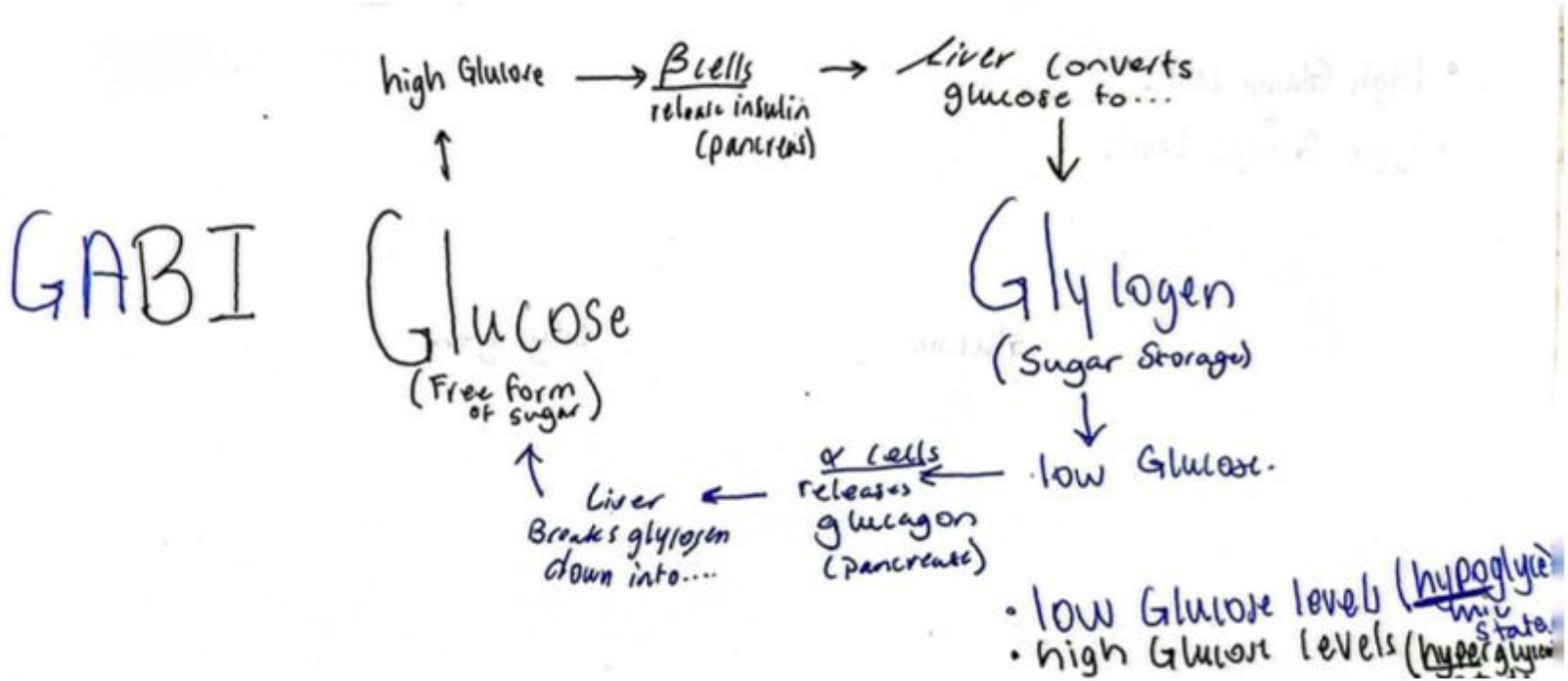
There are 2 endocrine glands influencing blood sugar levels.

1. Pancreas (specifically, the islets of langerhans)
    - Alpha cells: releases glucagon (increases glucose levels)
    - Beta cells: releases insulin (decreases glucose levels)
2. Adrenal glands (long and short term stress responses)



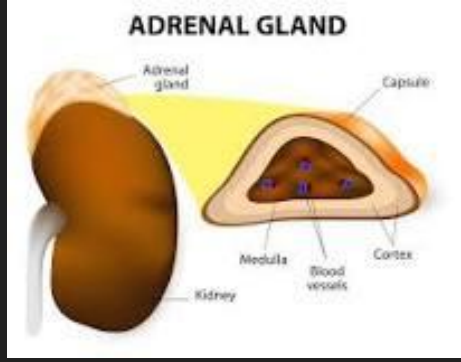



GABI


high Glucose
β cells
release insulin
(pancreas)
liver converts
glucose to...
Glucose
(Free form of sugar)
Glycogen
(Sugar Storage)
low Glucose.
α cells
releases
glucagon
(pancreas)
Liver
Breaks glycogen
down into....
• low Glucose levels (hypoglyce
• high Glucose levels (hyper

# Adrenal Glands

Consists of 2 glands:




1. Adrenal medulla (inner gland)
    - Controlled by Autonomic Nervous System (ANS)
        - Specifically, the sympathetic nervous system response
    - Produces epinephrine and norepinephrine
2. Adrenal cortex (outer gland): produces 3 steroid classes:

- **Glucocorticoids:** hormones that regulate carbohydrates, lipids, and proteins.
    - Also inhibits corticotropin (ACTH) release
    - E.g. cortisol (increases the amount of energy molecules → glucose, amino acids, fatty acids)
- **Mineralocorticoids:** hormones that regulate electrolyte and water balance.
    - E.g. aldosterone (increases reabsorption of sodium ions)
- **Sex hormones**

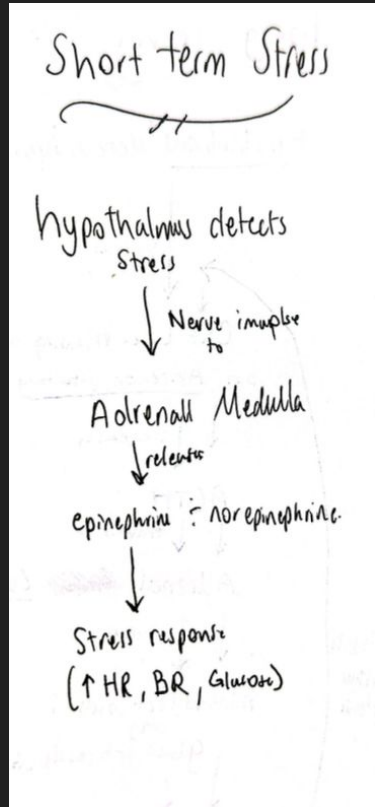
# Sympathetic vs Parasympathetic Response *Review*

| Organ | Sympathetic | Parasympathetic |
|---|---|---|
| heart | increases heart rate | decreases heart rate |
| digestive tract | decreases peristalsis | increases peristalsis |
| liver | increases the release of glucose | stores glucose |
| eyes | dilates pupils | constricts pupils |
| bladder | relaxes sphincter | contracts sphincter |
| skin | increases blood flow | decreases blood flow |
| adrenal gland | causes release of epinephrine | no effect |

# Hormones involved in the Stress Responses (short and long term stress)

# Short Term Stress Response

1. Hypothalamus sends Nerve Impulse to Adrenal Medulla
2. Medulla releases epinephrine and norepinephrine
3. Stress Response



# Long Term Stress Response

1. Stress detected by hypothalamus
2. Hypothalamus releases Corticotropin Releasing Factor (CRF) to the anterior pituitary
3. Anterior Pituitary secretes adrenocorticotropic hormone (ACTH)*
4. Travels to adrenal cortex
5. Release of mineralocorticoids and glucocorticoids
6. Increased concentrations of M and G = decrease in CRF release
7. Continuation of negative feedback loop

*ACTH = tropic hormone (i.e. target hormone)

# Short term Stress

hypothalmus detects Stress

↓ Nerve impulse to

Adrenal Medulla

↓ releases

epinephrine & norepinephrine.

↓

Stress response

(↑ HR, BR, Glucose)

# long term Stress

Hypothalmus detects Stress

↓ releases

CRF (i.e. releasing hormone) on Anterior pituitary.

↓ releases

ACTH

↓ travels to

Adrenal Cortex

↓ releases

mineralocorticoids (M) & glucocorticoids (G)

↓

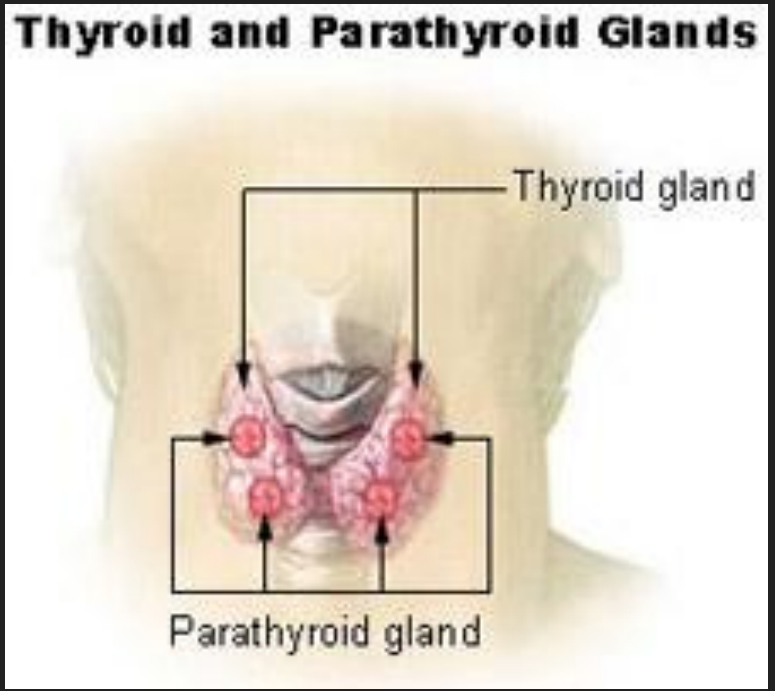
↑ [M] & [G]

inhibits further release

# Metabolism (thyroid and calcium control)

There are 3 endocrine glands involved in metabolism:

1. Thyroid (glucose breakdown)
2. Parathyroid (calcium control)
3. Anterior pituitary



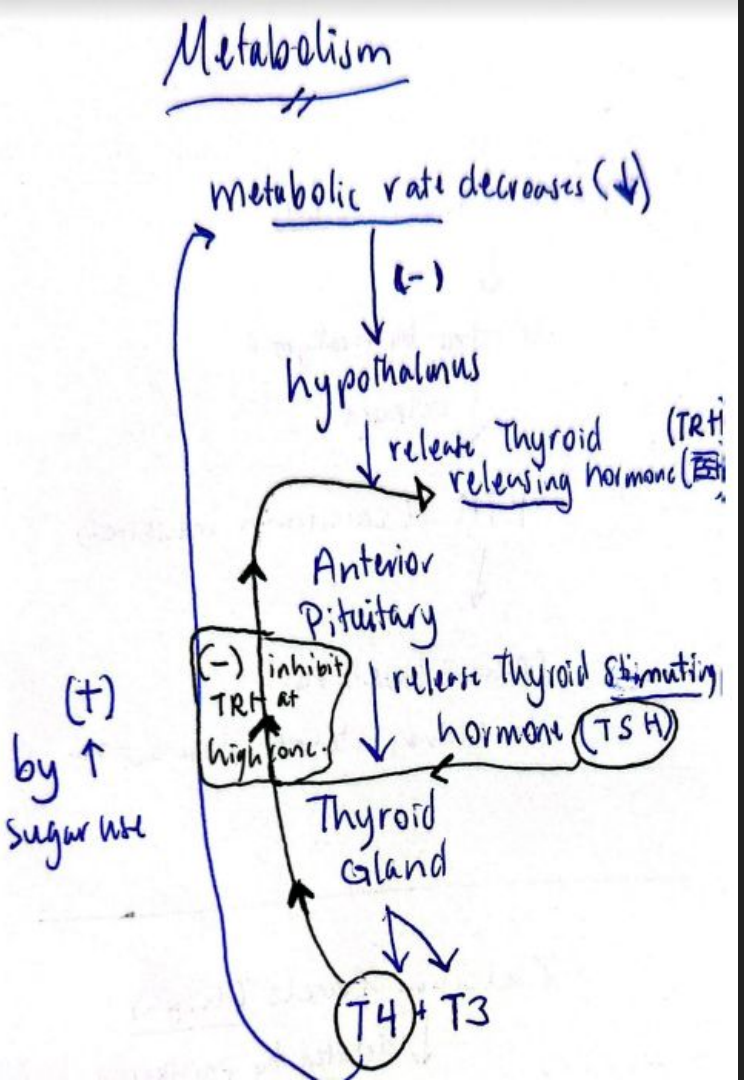
# Thyroid Gland

- Regulates metabolism (rate of glucose oxidation)
- Produces:
  - T3 and T4 (function: metabolism + tissue growth)
  - Calcitonin (lowers calcium levels)

# Metabolism Negative Feedback Loops

1. Body detects low metabolic rate
2. Hypothalamus releases TRH (thyroid releasing hormone)
3. Anterior Pituitary Gland releases TSH (thyroid stimulating hormone)
4. Thyroid gland releases T3 and T4 = increases in metabolic rate
5. High concentration of T4 and TSH = shuts off TRH release

# Metabolism


metabolic rate decreases (↓)
(-)
hypothalamus
release Thyroid releasing hormone (TRH)
Anterior Pituitary
(-) inhibit TRH at high conc.
release Thyroid Stimulating hormone (TSH)
Thyroid Gland
T4 + T3
(+) by ↑ sugar use

## Parathyroid

Operates independently of other glands

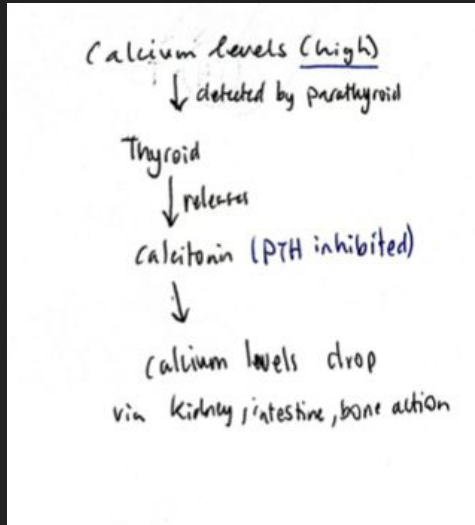
- Regulates calcium levels
- Produces: parathyroid hormone (PTH)
  - Increases calcium levels

## Parathyroid response to low calcium levels

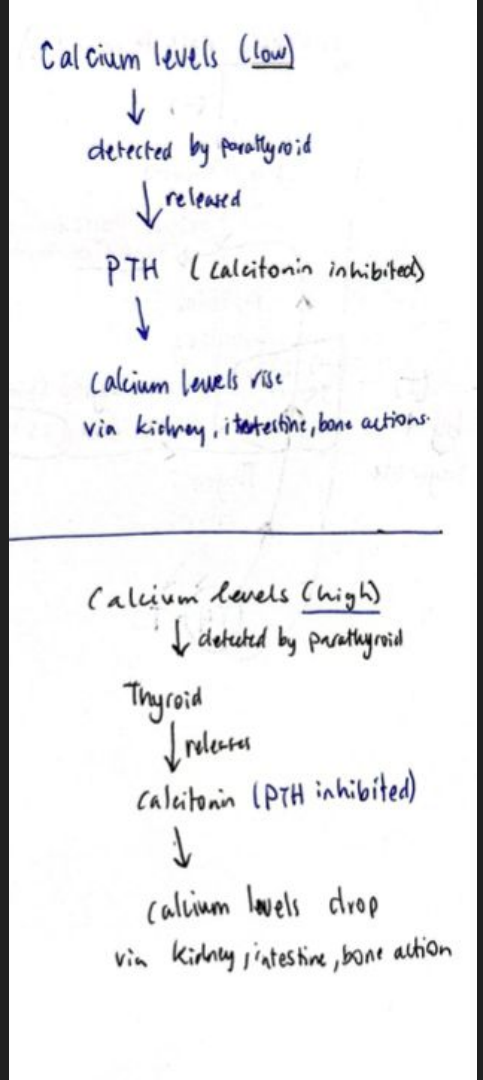
1. Parathyroid gland detects low calcium
2. Parathyroid releases parathyroid hormone (PTH) and inhibits the release of calcitonin
3. PTH acts on kidneys, intestines, and bones
   a. Kidneys and intestine absorb calcium released by our bones
4. Calcium levels rise

# Parathyroid Response for high calcium environment

1. Parathyroid gland detects high calcium levels
2. Parathyroid inhibits PTH and stimulates the release of calcitonin from the thyroid gland
3. Calcitonin acts on the kidneys, intestines, and bone
    a. Kidneys and intestine absorb less and bone deposits more bone



# Summary


Calcium levels (low)
detected by parathyroid
released
PTH (calcitonin inhibited)
Calcium levels rise
via kidney, intestine, bone actions
Calcium levels (high)
detected by parathyroid
Thyroid
releases
calcitonin (PTH inhibited)
Calcium levels drop
via kidney, intestine, bone action

# Human Growth Hormone (hGH)

Produced by the anterior pituitary

1. Extends the skeletal system (i.e. taller or shorter)
2. Promote protein synthesis
3. Promotes fat breakdown
    a. Increases amount of fatty acids in the blood = different energy source

# Water Balance

# General Idea behind water balance

Drinking more water (i.e. intake increases) = increased urine output and vise versa

Water balance involves 2 hormones:

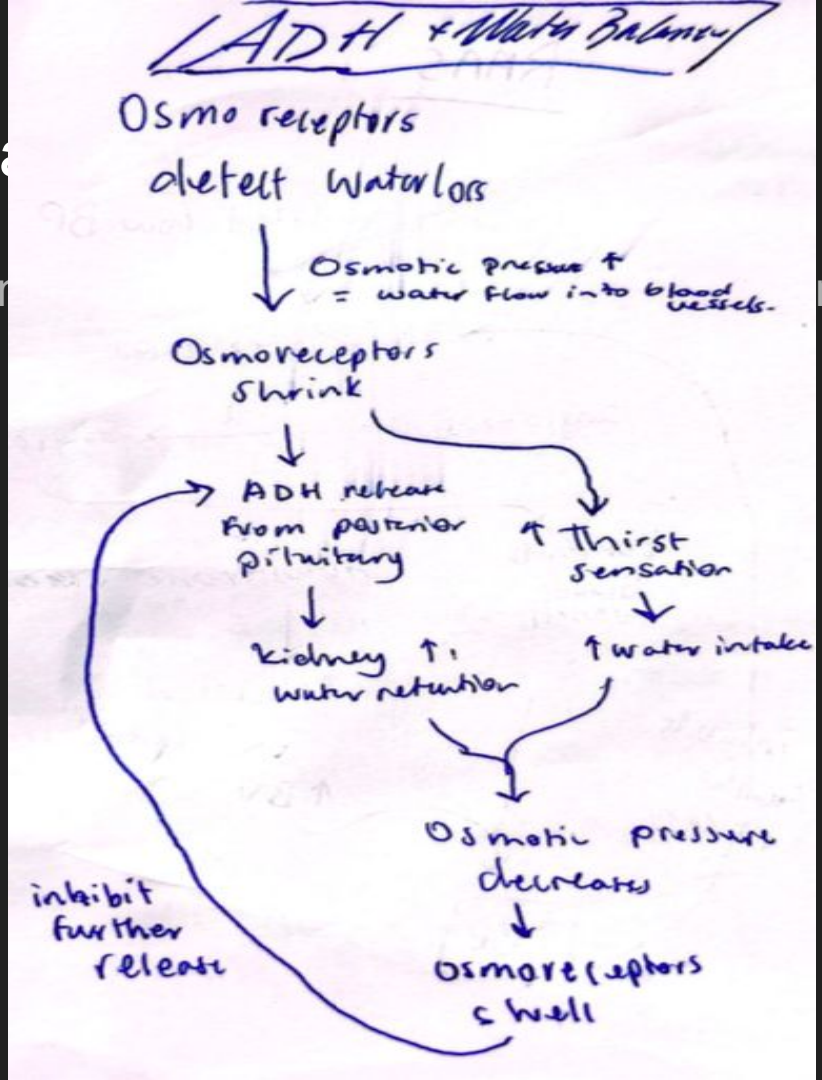
1. Antidiuretic hormone (ADH)*water retention
2. Aldosterone *sodium retention (water too)

# Feedback loop for water balance

1. **Osmoreceptors detect water loss**
2. **Blood solutes increase in concentration (i.e. hypertonic)**
3. **Osmotic pressure increases resulting in water flowing into the blood vessel**
4. **Osmoreceptor shrinks resulting in ADH release from the posterior pituitary + sensation of thirst**
5. **ADH acts on kidneys = increased water retention + drink more water**
6. **Osmotic pressure decreases**
7. **Osmoreceptor swells**
8. **Hypothalamus inhibits ADH release**

# Metabolic pa

Note: water reter r total water intake



# HOW Does the Body Detect Changes in BLOOD VOLUME and BLOOD VOLUME?

**Juxtaglomerular apparatus (JGA):** Part of kidney glomerulus that detect low blood pressure

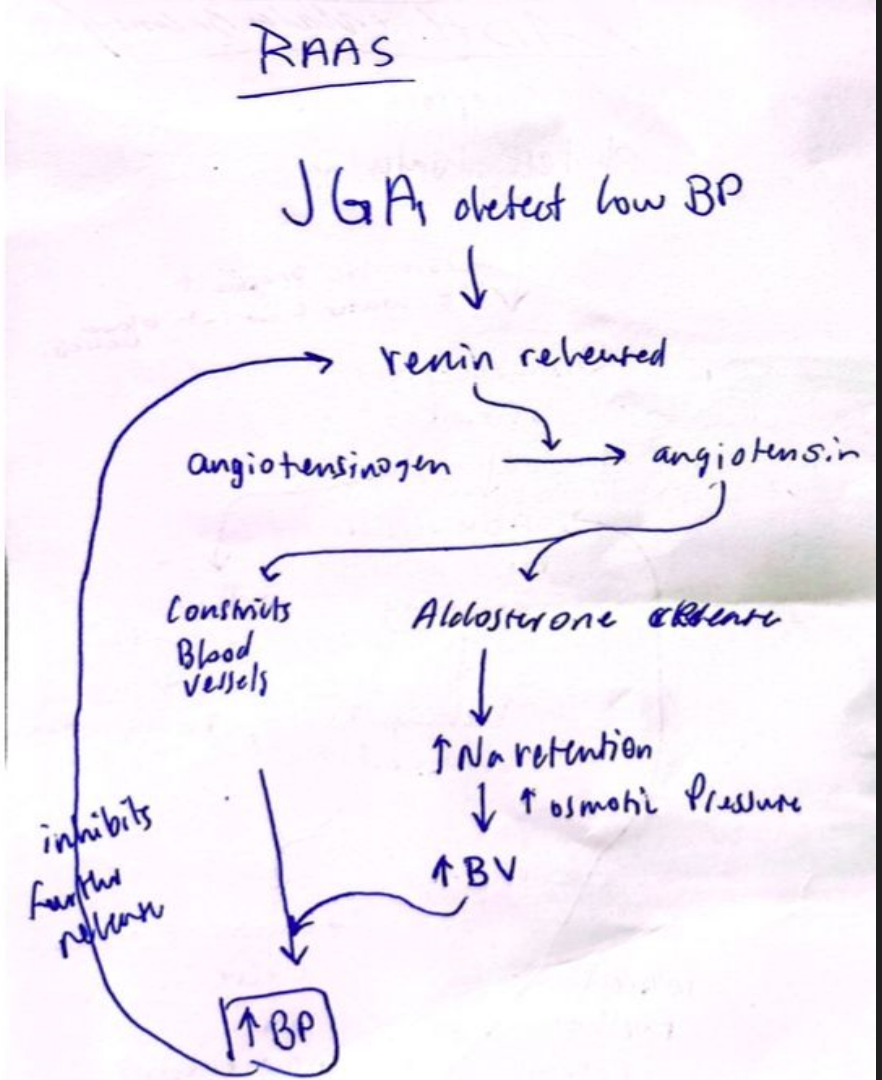
Note: in the human body blood volume and pressure are directly proportional (if one increases the other does also)

# Renin-angiotensin-aldosterone system (RAAS)

Feedback loop triggered by large fluid loss (e.g. hemorrhage)

1. JGA detects low blood pressure
2. JGA releases renin
3. Renin helps convert angiotensinogen into angiotensin in the liver
4. Angiotensin constricts blood vessels and stimulates the release of aldosterone
5. Aldosterone (acting on the distal tube and collecting duct of the kidney) increase sodium retention increases osmotic pressure = increased water uptake into the blood
6. Blood volume increases causing blood pressure to increase

# RAAS


JGA detect low BP
renin released
angiotensinogen
angiotensin
Constricts Blood vessels
Aldosterone
↑Na retention
↑ osmotic Pressure
↑BV
inhibits further release
↑BP

# The Stress Response

- Characterized by increased blood flow, heart rate and amount of energy sources available

Response uses the nervous and endocrine systems

- Nervous system (i.e. sympathetic NS)
  - Increases the heart rate and blood flow to muscles
- Endocrine system
  - Increases the amount of available energy sources (e.g. glucose, amino acids, and fatty acids)
  - Increases the heart rate also

## Hormones involved in the stress response (glucose regulation)

***Hormones increase the amount of available energy sources***

1. **Epinephrine (initial response):** increases blood glucose and heart rate
2. **Cortisol (long term stress):** increases amount of AA, glucose and fatty acids in the blood
3. **Glucagon (stimulated):** increases glucose levels
4. **Insulin (inhibited):** glucose uptake is inhibited

# Hormones involved in the stress response
(blood pressure and volume regulation)

***Hormones increase blood pressure***

1. RAAS (increases BP + moves blood away from kidney and towards the muscles)
2. ADH (water retention to maintain proper fluid levels)

# Problems arising from prolonged stress

Long periods away from homeostasis = bad

Examples:

High blood glucose → high blood pressure and increased water loss

High blood pressure → risk of blood clots and blood vessel rupture

High heart rate → risk of heart damage and increased blood pressure

## Prostaglandins

Group of hormones that act on the cells that produce them

- Help repair cell damage via inflammation, increased blood flow and blood clotting.

Note: they are also involved in increasing uterine contractions during parturition (i.e. the process of giving birth)